FEB 1 1924

Single Numbers, 12/6 net. [No. 43.

Volume commence in JULY. Title and Index
Cases for Binding, 4/- net; or the Volume
of the four numbers, for 7/6 net, post free.

British Journal of Surgery

UNDER THE DIRECTION OF THE FOLLOWING
EDITORIAL COMMITTEE:

Sir ALEXANDER MacCORMICK (Sydney)
Sir GEO. H. MAKINS, G.C.M.G., C.B., LL.D. (London)
WM. ERNEST MILES (London)
A. B. MITCHELL, O.B.E. (Belfast)
HENRY A. MOFFAT, D.S.O. (Capetown)
RUTHERFORD MORISON (Newcastle-on-Tyne)
Sir THOMAS MYLES, C.B. (Dublin)
CHARLES A. PANNETT (London)
PARRY (Glasgow)
Sir D'ARCY POWER, K.B.E. (London)
SIDNEY W. F. RICHARDSON (Capetown)
PERCY SARGENT, C.M.G., D.S.O. (London)
JAMES SHERREN, C.B.E. (London)
GRAHAM S. SIMPSON (Sheffield)
THOMAS SINCLAIR, C.B. (Belfast)
Sir HAROLD J. STILES, K.B.E. (Edinburgh)
HENRY ALEXIS THOMSON, C.M.G. (Edinburgh)
BEN DERY TURNER (Newcastle-on-Tyne)
GEORGE E. WAUGH (London)
Sir W. I. de COURCY WHEELER (Dublin)

..., Editorial Secretary.

JANY. 1924

WRIGHT & SONS LTD.
SIMPKIN, MARSHALL, HAMILTON, KENT & CO. LTD.
BOMBAY: W. THACKER & CO.
NEW ZEALAND: WHITCOMBE & TOMBS LTD.
..., NEW YORK, Sole Agents.

Indispensable Sutures

LONDON HOSPITAL CATGUT

Each box of sterile "Ultratan" Catgut for surgical work bears a label stating that "every batch of catgut is passed by a consulting bacteriologist before it is issued."

"Ultratan" Catgut is prepared at the London Hospital, and is in continuous use in the 13 operating theatres there.

It is claimed for London Hospital Catgut:

1—Sterilisation commences immediately the intestine is split.

2—The tensile strength provides a wide margin of safety.

3—Every batch is passed by a consulting bacteriologist.

Descriptive booklet will be sent post free upon application to the sole distributors:—

Allen & Hanburys Ltd.

48, WIGMORE ST., LONDON, W.1

THE
BRITISH JOURNAL OF SURGERY

VOL. XI. JANUARY, 1924. No. 43.

EPONYMS.

BY SIR D'ARCY POWER, K.B.E., LONDON.

XI. BELL'S PALSY.

THE account of Bell's Palsy appears in the second part of the *Philosophical Transactions of the Royal Society of London* for the year 1821, pp. 398–424. Contribution XXVIII is entitled "On the Nerves; giving an account of some experiments on their structure and functions, which lead to a new arrangement of the system. By Charles Bell, Esq. Communicated by Sir Humphry Davy, Bart., P.R.S., read July 12, 1821." Bell decided of set purpose to ascertain the course and determine the functions of the nerves of respiration. "The first point of enquiry", he says, "naturally is, how many of the muscles are combined in the act of respiration? and the second question, By what means are these muscles, which are seated apart from each other, and many of them capable of performing distinct offices, combined together in respiration? It may sound oddly to speak of the respiratory nerve of the face, of the neck, and of the shoulder; but when a post-horse has run its stage, and the circulation is hurried, what is his condition? Does he breathe with his ribs only; with the muscles which raise and depress the chest? No. The flanks are in violent action; the neck as well as the chest is in powerful excitement; the nostrils as well as the throat keep time with the motion of the chest. So if a man be excited by exercise or passion, or by whatever accelerates the pulse, the respiratory action is extended and increased; and instead of the gentle and scarcely perceptible motion of the chest, as in common breathing, the shoulders are raised at each inspiration, the muscles of the throat and neck are violently drawn, and the lips and nostrils move in time with the general action; and if he does not breathe through the mouth, the nostrils expand, and fall in time with the rising and falling of the chest; and that apparatus of cartilages and muscles of the nose (which are as curious as the mechanism of the chest, and which are for expanding these air tubes) are as regularly in action as the levator and depressor muscles of the ribs. It is quite obvious that some hundred muscles thus employed in the act of breathing, or in the common actions of coughing, sneezing, speaking and singing, cannot be associated without cords of connection or affinity, which

combine them in the performance of these actions: the nerves which serve this purpose I call respiratory nerves."

After considering some points in the comparative anatomy of the nerves, Bell enumerates the following as *respiratory nerves* in accordance with their functions:—

"1. *Par vagum*, the eighth of Willis, the *pneumogastric nerve* of the modern French physiologists.

"2. *Respiratory nerve of the face*, being that which is called *portio dura* of the seventh. This nerve like the last goes off from the lateral part of the *medulla oblongata*, and, escaping through the temporal bone, spreads wide to the face. All those motions of the nostril, lips or face generally, which accord with the motions of the chest in respiration, depend solely on this nerve. By the division of this nerve the face is deprived of its consent with the lungs and all expression of emotion. This part of the enquiry will be found very interesting.

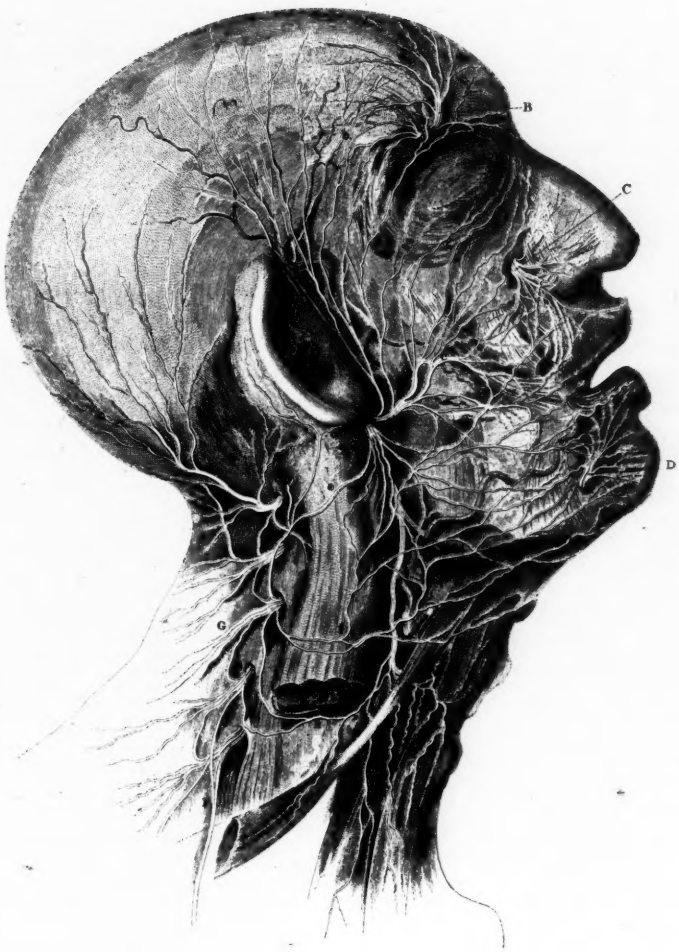
"3. *Superior respiratory nerve of the trunk* being that which is called *spinal accessory*. This nerve has exceedingly puzzled anatomists from the singular course which it pursues.

"4. *Great internal respiratory nerve*. The *phrenic*, or *diaphragmatic* of authors. This is the only nerve of the system which has been known as a respiratory nerve.

"5. *The external respiratory nerve*. This has a similar origin with the preceding nerve. It comes out from the cervical vertebræ, and is connected with the phrenic nerve. It runs down the neck, crosses the cervical and axillary nerves, passes through the axilla, and arrives on the outside of the ribs, where, it is scarcely necessary to observe, the muscles are already supplied by nerves coming out betwixt the ribs from the system of regular nerves.

"These four last-mentioned nerves govern the muscles of the face, neck, shoulders and chest in the actions of excited respiration, and are absolutely necessary to speech and expression. But there are other nerves of the same class which go to the tongue, throat, and windpipe, no less essential to complete the act of respiration. These are the glossopharyngeal nerve, the lingual, or ninth of Willis, and the branches of the par vagum to the superior and inferior larynx."

These nerves are then considered in detail. He says "of the respiratory nerve of the face, being that which is called portio dura of the seventh (Portio dura nervi acustici, Sympatheticus parvus by Winslow, Faciale by Vicq d'Azyr) Plate *Aabcd*. This nerve does not exist except where there is some consent of motions established betwixt the face and the respiratory organs. In fishes, this nerve, instead of being distributed forward to the face, passes backward to the muscles of the gills. In fact there is, properly, no *portio dura* of the seventh in fishes, the nerve resembling it being a branch of the *par vagum*. A short description of this nerve in the human body will be necessary to our enquiry." Bell traces its anatomical course from the superior and lateral part of the medulla oblongata, through the temporal bone, to its distribution on the face. He states that in texture it corresponds with the structure of the *par vagum* and differs from that of the *trigeminus*.



DRAWING BY SIR CHARLES BELL TO ILLUSTRATE
THE RESPIRATORY SYSTEM OF NERVES

The function he arrived at experimentally: "An ass being thrown, and its nostrils confined for a few seconds, so as to make it pant and forcibly dilate the nostrils at each inspiration, the portio dura was divided on one side of the head; the motion of the nostril of the same side instantly ceased, while the other nostril continued to expand and contract in unison with the motions of the chest.

"On the division of the nerve the animal gave no sign of pain; there was no struggle nor effort made when it was cut across.

"The animal being untied and corn and hay given to him he eat without the slightest impediment.

"An ass being tied and thrown, the superior maxillary branch of the fifth nerve was exposed. Touching this nerve gave acute pain. It was dvided, but no change took place in the motion of the nostril; the cartilages continued to expand regularly in time with the other parts which combine in the act of respiration; but the side of the lip was observed to hang low and it was dragged to the other side. The same branch of the fifth was divided on the opposite side, and the animal let loose. He could no longer pick up his corn; the power of elevating and projecting the lip, as in gathering food, was lost. To open the lips the animal pressed the mouth against the ground, and at length licked the oats from the ground with his tongue. The loss of motion of the lips in eating was so obvious that it was thought a useless cruelty to cut the other branches of the fifth.

"The experiment of cutting the respiratory nerve of the face or *portio dura*, gave so little pain that it was several times repeated on the ass and dog, and uniformly with the same effect. The side of the face remained at rest and placid during the highest excitement of the other parts of the respiratory organs. When the ass, on which the respiratory nerve of the face had been cut, was killed, which was done by bleeding, an unexpected opportunity was offered of ascertaining its influence, by the negation of its powers on the side of the face where it was cut across.

"When an animal becomes insensible from loss of blood, the impression at the heart extends its influence in violent convulsions over all the muscles of respiration; not only is the air drawn into the chest with sudden and powerful effort, but at the same instant the muscles of the mouth, nostrils and eyelids and all the side of the face, are in a violent state of spasm. In the ass where the respiratory nerve of the face had been cut, the most remarkable contrast was exhibited in the two sides of its face; for whilst the one side was in universal and powerful contraction, the other, where the nerve was divided, remained quite placid.

"From these facts we are entitled to conclude, that the *portio dura* of the seventh, is the respiratory nerve of the face.

"The actions of sneezing and coughing are entirely confined to the influence of the respiratory nerves. When carbonate of ammonia was put to the nostrils of the ass whose respiratory nerve had been cut, that side of the nose and face where the nerves were entire, was curled up with the peculiar expression of sneezing; but on the other side, where the nerve was divided, the face remained quite relaxed, although the branches of the fifth pair and the sympathetic were entire. The respiratory nerve of one side of the face

of a dog being cut, the same effect was produced; the action of sneezing was entirely confined to one side of the face.

"On cutting the respiratory nerve on one side of the face of a monkey, the very peculiar activity of his features on that side ceased altogether. The timid motions of his eyelids and eyebrows were lost, and he could not wink on that side; and his lips were drawn to the other side, like a paralytic drunkard, whenever he showed his teeth in rage.

"We have proofs equal to experiments, that in the human face the actions of the muscles which produce smiling and laughing, are a consequence of the influence of this respiratory nerve. A man had the trunk of the respiratory nerve of the face injured by a suppuration, which took place anterior to the ear and through which the nerve passed in its course to the face. It was observed that in smiling and laughing, his mouth was drawn in a very remarkable manner to the opposite side. The attempt to whistle was attended with a ludicrous distortion of the lips; when he took snuff and sneezed, the side where the suppuration had affected the nerve remained placid, while the opposite side exhibited the usual distortion.

"Thus it appears that, whenever the action of any of the muscles of the face is associated with the act of breathing, it is performed through the operation of this nerve. I cut a tumour from before the ear of a coachman; a branch of the nerve which goes to the angle of the mouth was divided. Some time after he returned to thank me for ridding him of a formidable disease, but complained that he could not whistle to his horses."

Bell then proceeds to examine the function of the fifth nerve, and shows that it is sensory by evidence derived both from experiment and clinical experience, and then "having brought this investigation to a conclusion, some perhaps, fatigued by its details, may ask to what does this discussion lead?

"Were we to enquire no further, and to rest content with the inference that the two sets of nerves distributed to the face have distinct functions; even this must prove useful to the surgeon and physician. To the surgeon it must be useful in performing operations on the face, as well as in observing the symptoms of disease; but especially to the physician must these facts be important; he will be better able to distinguish between that paralysis which proceeds from the brain, and that partial affection of the muscles of the face, when, from a less alarming cause, they have lost the controuling influence of the respiratory nerve.

"Cases of this partial paralysis must be familiar to every medical observer. It is very frequent for young people to have what is vulgarly called the blight; by which is meant, a slight palsy of the muscles on one side of the face, and which the physician knows is not formidable. Inflammations of glands seated behind the angle of the jaw will sometimes produce this. All such affections of the respiratory nerve will now be more easily detected; the patient has a command over the muscles of the face, he can close the lips, and the features are duly balanced; but the slightest smile is immediately attended with distortion, and in laughing and crying the paralysis becomes quite distinct. The knowledge of the sources of expression teaches us to be more minute observers."

Sir Charles Bell afterwards collected the various papers upon the nervous system and published them with some alterations and in greater detail in a single volume which ran through several editions. It is clear that his views were not received favourably at first, for in a clinical lecture on a case of facial paralysis he says: "I remember very well many years ago, when these ideas on the nervous system first occurred to me, that I took the opportunity of explaining them to a great philosopher (Dr. Young) who was respected as a man of almost universal information and great intelligence. I took to him the class drawings from which these are copies. Captain Kater, who was present, was very desirous to understand the whole doctrine. I began by saying, 'The respiratory nerves of the face'. Dr. Young was in bad health, and irritable. He said, 'Who ever heard of respiration of the face?—that will never do'. He would not hear of the idea of respiration of the face. No wonder; as a chemical philosopher, he had only been accustomed to think of respiration as connected with the great function of the oxygenation of the blood. It was a new idea to him to think of the act of respiration as connected with the face." This is a remarkable testimony to the novelty of Bell's views, for Dr. Thomas Young, "the founder of physiological optics", who was equally great as a physicist and as an Egyptologist, was a man of universal erudition. Captain Kater, the Treasurer of the Royal Society, is still remembered by the extraordinarily accurate seconds pendulum which he invented, as well as by the fact that he prepared the standard measures for the Russian Government in 1815.

The novelty of Bell's teaching sometimes reacted unfavourably upon his pupils, for "A young gentleman went up to the College of Surgeons in order to pass. He was examined by my excellent friend Mr. Abernethy, who was then in all his vigour of mind, but who was ever a little sarcastic. He asked this young man to tell him the parts that combined in the act of breathing; and when he had enumerated the common parts, he added, 'the muscles of the perineum'. At which Mr. Abernethy sneered and repeated, 'Perineum! what has that to do with it?' My young friend proceeded to explain, that, although in the common act of respiration, the muscles there were not concerned, yet that in all violent excitements of respiration, such as in coughing, sneezing and straining, he had been taught (and he believed correctly), that unless there was a combined action there, the parts would be protruded; that unless the muscles at the opening of the pelvis were in correspondence with the diaphragm, there could be no protection of the viscera, but a protrusion of it. He added, 'I am sensible there is a corresponding action every time I cough or sneeze'." Sir Charles Bell gives no indication of Abernethy's reply, but, considering the plain speaking of the time, it is perhaps better left to the imagination.

The illustration is copied from Sir Charles Bell's own drawing engraved by Basire for the *Philosophical Transactions*.

OPERATION SHOCK.*

By JOHN FRASER, Edinburgh.

Operation shock or surgical shock is one of the formidable developments which every now and again jeopardize and even nullify the best surgical efforts. As we have learnt more regarding its origin and pathology its ravages have been correspondingly crippled, yet the evidences are sufficiently manifest to make it a very real danger. It is one of those factors which has delayed and curtailed the evolution of surgical progress, and, were it possible to eliminate its appearance, the surgical horizon would correspondingly enlarge, and the fulfilment of many surgical dreams might be realized.

In the surgery of childhood, in the surgery of accident, and in that most extreme form of accident surgery—the surgery of war, surgical shock has ever played a formidable part. Therefore a condition which has so limited our surgical progress, sullied our best efforts, and increased our mortality, must surely demand the closest attention.

The subject is one of the widest consideration ; it is replete with problems, both clinical and physiological, and the exact nature of much of it is still unknown to us. We get an idea of the complexity of the problem when we attempt to summarize the steps by which our knowledge of the subject has accumulated, and with this aim in view it is convenient to divide the progress of our knowledge into two periods—(*A*) to the end of 1915, and (*B*) subsequent to 1915. This second period has been distinguished by the opportunities which the misfortunes of the European war afforded for the study of the condition, and the corresponding efforts which various scientific bodies made to elucidate and to combat the problem.

A.—PERIOD TO THE END OF 1915.

It may be said that during this period opinion had tended to crystallize round certain individual theories, and, though many of these views have suffered eclipse, we may learn something from a short consideration of the more important.

1. **The Theory of Exhaustion of the Vasomotor Centre.**—This view came to be, and is still, associated with the names of Crile[1] and Mummery[2]. It was argued that sensory stimuli produce a rise of blood-pressure from the irritation of 'pressor nerves', and the continuation of such afferent stimuli leads eventually to exhaustion of the vasomotor system, dilatation of the peripheral vessels, and a subsequent fall of blood-pressure. In regions in which only a depressor afferent nerve exists (as in the testis, for example), stimulation results in a correspondingly great degree of shock.

---

* Read at the Sixth Meeting of the International Society of Surgery in London, in July, 1923.

This theory suffered from two destructive criticisms—that the vessels in shock are contracted (Malcolm,[3] Seelig and Lyon[4]), and that it can be demonstrated experimentally that even in the most profound shock the vasomotor centre is not exhausted (Seelig and Lyon[4], Porter and Quinley[5]).

2. **The Acapnia Theory (Yandell Henderson).**—The activity of the respiratory centre is largely governed by the amount of CO_2 in the blood; an excess of CO_2 produces stimulation of respiration, a diminution of CO_2 results in several deep respirations and a pause in the respiration, which is known as 'apnœa'. According to Henderson,[6] the deep and rapid breathing which painful stimuli effect so reduces the CO_2 that a condition (acapnia) results which is the primary cause of shock. Secondary to the acapnia it was assumed that there was a failure of the venous pressure, an accumulation of blood in the venous spaces, impoverishment of the right auricle, and a resulting fall in blood-pressure.

In confirmation of his view Henderson has quoted experiments by Sherrington and Copeman[7] which seem to indicate that a diminution of CO_2 results in a tendency for fluid to pass from the blood plasma into the tissues, leaving the blood concentrated. The sequence which is assumed in Henderson's theory may be summarized thus: hyperpnœa, acapnia, failure of the vasomotor pressor mechanism, fall of blood-pressure, and possibly a secondary concentration of the blood (oligæmia).

It must be of interest to the abdominal surgeon to recall how Henderson demonstrated what he believed to be a local manifestation of his view. He claimed that when the abdomen is opened and the intestines exposed, there is relatively a great loss of CO_2 from the visceral surfaces, a loss which he estimated as forty times as great as that from the skin. Locally this change was manifested by vascular dilatation, muscular paresis, apnœa, and eventually by general manifestations of surgical shock.

Based upon his conception of the physiological pathology, Henderson instituted a programme of treatment for shock which included slow respiration, breathing through a long tube, so that expired air loaded with CO_2 was re-breathed, pouring warm saline saturated with CO_2 into the abdominal cavity, transfusing warm saline saturated with CO_2, and allowing the subject to breathe in and out of a bag containing air or oxygen.

While the Crile-Mummery and the Henderson theories found most acceptance, there were other views, of which only a summary need be given.

3. **The Boise Theory.**—Boise[8] regarded the fall in blood-pressure as being secondary to a cardiac condition, and he believed that there was a tendency for the heart to fail in systole. As we shall show, there is abundant evidence that the cardiac condition is never the primary fault in true surgical shock.

4. **The Meltzer Theory.**—The foundation of Meltzer's[9] theory is based upon the supposition that the stimulus of injury resulted in an inhibition of the functions of the spinal cord, and in the more extreme degrees in an inhibition of the medulla and its centres. This view seems to have originated in the demonstration of the clinical fact that, when the abdomen is opened, or even when an extensive skin dissection is made, there is a resulting inhibition of the intestinal peristaltic movements. No reliable experimental evidence

seems to have been produced which supports the possibility of such being a reflex spinal inhibition.

Other views which have been held only demand a passing notice. Certain of them contain what one may term 'partial truths'. Kinnamann[10] believed that disturbances of the thermogenic functions played an important and a primary part; Jaboulay[11] attached importance to the formation of an irreducible hæmoglobin; Bainbridge and Parkinson[12] suggested that the loss of chromaffin tissue which can be manifested in shock might be a responsible feature; Schur and Weisel[13] demonstrated a similar loss of chromaffin tissue after anæsthesia, and suggested the relationship of this fact to shock; Vale[14] described the concentration of the blood (oligæmia) which is recognized in the later stages of shock, and at one time it seemed as though this fact held much of the secret of shock; Bissel[15] described the occurrence of severe shock in relation to pulmonary fat embolism, and he suggested that such a mechanical error might be a constant feature in the condition.

The above summary may be said to represent the various attitudes of opinion to the problem prior to 1915.

B.—PERIOD SUBSEQUENT TO 1915.

The second stage in the attempt at elucidation of the shock problem was distinguished by the occurrence of the European war. The serious manifestations of the disorder which then became evident began to arouse widespread attention. Reports from the various centres of war made constant allusion to the ravages of shock and to the high mortality which it claimed. Early in 1916 a carefully organized effort was made to elucidate the problem, and in this country the Medical Research Committee undertook the task. It is to this body and to various observers who were associated with it that we owe much of our present knowledge.

A Definition of Shock.—Before we can appreciate the various changes which appear to play a part in the complex problem of the shock condition it is essential that we have some concrete definition of what the term 'surgical shock' implies. Such a definition is difficult, especially if it is to be in any way inclusive, but surgical shock may be defined as *a state of depression of all the vital functions of the body, the state being primarily induced by the infliction of injury on the body tissues, and being characterized by a progressive fall of the blood-pressure.*

The Clinical Features.—The clinical features which develop as the result of surgical shock vary according to the degree of the shock, but in a well-established case they may be grouped somewhat as follows. The individual may be described as being in a state of prostration. Mentally he is apathetic and indifferent; it is with difficulty that he can be roused from his apathy, and yet when roused he can answer clearly and intelligently, though faintly. The face is pale and drawn, the eyes are sunken, the cheeks hollow, the lips and ears pallid or dusky in appearance, and beads of perspiration may stand out on his face. The skin has a grey, dusky appearance, and it is cold and clammy to the touch; the musculature shows evidences of depression in the languid character of its movements. The pulse is rapid and fluttering, and

it may be all but imperceptible at the wrist. The respiration is shallow, sighing, and irregular, and a noticeable feature is the low temperature of the expired air. The mouth is parched, there is an intolerable thirst, and an impressive feature in the picture is the diminished sensibility to pain. Such are the collective evidences which we conveniently group under the term 'surgical shock', and the picture justifies the definition, because it is no other than a devitalization of all the essential and vital functions of the body.

The exciting factor of the train of symptoms is trauma of some description, whether it be accident, wound, or surgical operation; and one of the most impressive features in the condition is the rapidity with which an active, healthy man is converted into a collapsed and helpless invalid.

The Clinical Pathology of the State of Shock.

It is reasonable that we should ask ourselves the explanation of the development of this remarkable and often sudden transformation. I believe it was Professor Cannon[16] who first suggested that it is convenient to arrange the disturbances of shock into four groups—(1) *Circulatory*; (2) *Respiratory*; (3) *Motor*; and (4) *Sensory*; and if we now attempt to explain the individual changes in each of these group disturbances, we may be able to obtain an accurate idea of the series of errors which are at work. This would appear to be a more rational way of considering the problem than of attempting to prove or to disprove any individual theory.

1. **The Circulatory Disturbances.**—The essential demonstrable error as far as the circulation is concerned is the progressive and often sudden fall of the blood-pressure. Other features, which are obviously secondary to the blood-pressure change, are the small, rapid pulse, the pallor of the body surface, and the low temperature of the skin. The problem, therefore, is to explain the progressive fall of the blood-pressure. In a condition of health there are three factors which maintain the blood-pressure at a normal level: (i) The contracting heart; (ii) The vasomotor mechanism, which controls the tonicity of the vessel walls; and (iii) The blood-volume; an error in one or other of these would explain the fall in blood-pressure. Let us therefore inquire whether it is possible to locate the error.

i. *The Heart.*—It was suggested by Howell that a paralysis of the cardio-inhibitory centre might occur in shock, the effect being to produce an increase in the rapidity of the heart-beat and therefore a weakening of its efforts. The experiments of Mann[17], however, have shown that this suggestion has no foundation, for even in the most profound degree of shock, stimulation of the central end of the cut vagus resulted in a reflex slowing of the heart. There are also two clinical facts which disprove any possibility of error in the nerve mechanism of the heart: (*a*) If adrenalin is administered during deep shock, it will be found that the heart begins to miss beats owing to the stimulation of its inhibitory centre by the adrenalin; and (*b*) Where shock is associated with a head injury which results in an increase of intracranial pressure, the heart is slowed owing to stimulation of the cardio-inhibitory centre, even though the shock may be profound.

There is, therefore, abundant evidence that, as far as the nerve mechanism

of the heart is concerned, no error is to be found. It remains to consider the possibility of the heart muscle being the responsible feature.

Mann's[18] experimental work supplies the answer to this query, because he has shown that, apart from myocardial disease, an efficient contraction of the cardiac muscle can be guaranteed as long as the heart is properly supplied with blood. The persistence of the low blood-pressure in established shock will of course result in myocardial weakness, but in this event the change is secondary. The low blood-pressure is therefore not traceable to any error in the heart or its related nervous mechanism.

ii. *The Vasomotor Mechanism.*—It was a natural assumption that the low blood-pressure might be due to a relaxation of the walls of the arterioles, and certain of the accepted theories of shock were founded upon this assumption. We have the evidence of many observers, however, that the fault does not lie in this direction. The vasomotor centre is capable of response in fully-established shock (Seelig and Joseph[19], Guthrie[20]). It is possible that on receipt of the injury there may be a temporary functional inhibition of the centre, but there is no evidence of a progressive exhaustion of it through a reflex origin. Crile and Dolley[21] have described histological evidence of exhaustion of nerve-cells in the central nervous system, a process in which presumably the vasomotor centre might share, but there is a growing belief that these changes (chromatolysis) are produced by anæmia and are not the result of harmful afferent stimuli (Mott).

Assuming that the error does not lie in the vasomotor centre, the possibility has to be considered of the low blood-pressure being due to a relaxation or to a paralysis of the muscular tissue of the arterial or venous system, more especially of the splanchnic vessels. We find, however, that the possibility has been denied, and it is asserted by Malcolm[3] and others that the vessels are actually contracted during shock.

Those who have had an opportunity of performing abdominal operations during deep shock are unanimous in denying the possibility of a splanchnic dilatation, and as a matter of fact, the pallor which is so characteristic of shock is rather an indication of vascular contraction than of any degree of dilatation. The evidence which we possess, therefore, is in favour of the vasomotor centre and its associated connections remaining active during the introductory stages of shock.

iii. *The Blood-volume.*—A diminution in the volume of blood in circulation would explain the low arterial pressure of shock, and in view of the fact that the heart with its associated nervous mechanism and the bulbovasomotor centre appear to be unimpaired, suspicion very naturally falls upon the factor. In the vital-red method we have at our disposal a means of estimating the blood-volume, and the investigations of Keith,[22] Robertson and Bock,[23] and others have shown that when shock is established the blood-volume in active circulation is reduced. This therefore would seem to be the explanation of the low blood-pressure which so characteristically distinguishes the circulatory changes.

The observer is now driven back to the question: Why is the blood-volume in active circulation reduced? It is doubtful if a complete answer to the question is yet available. Cannon has put the question in an appropriate

form when he speaks of "the problem of the lost blood", and a similar impression is implied when we speak of a shocked individual having 'bled into his own vessels'.

There are two localities in which blood might collect in sufficient volume to effect a reduction of the blood-pressure—the splanchnic area and the capillary area. The splanchnic was long considered to be the situation in which blood collected during shock, and there are both anatomical and physiological reasons which made the possibility a likely one; but we have been driven from this conclusion by the evidence of the practical surgeon, that during deep shock the splanchnic vessels are actually contracted instead of being dilated.

There remains therefore the capillary system. It has been demonstrated that when an individual suffers from shock the red blood-count taken from the superficial capillaries is considerably higher than that taken from the veins. The more profound the shock the greater is this discrepancy, so that in profound shock the capillary count may exceed the venous by as much as 2,000,000 corpuscles per c.mm. Since the venous count is approximately normal, one has to conclude that there is a stagnation of corpuscles in the capillaries. The results obtained by enumeration can be controlled and confirmed by hæmoglobin and hæmatocrit estimations.

Our knowledge of the capillary system is incomplete. The recent work of Krogh[24] gives some idea of the vast possibilities of the system in the establishment and in the maintenance of disease. The idea that it is merely a finely divided mechanical connection between the arterial and the venous systems must be abandoned—it is an independent system, and as such is susceptible to influences to which it responds in a variety of ways.

When we appreciate the fact that one-tenth of the muscular bulk of the body is composed of capillary tissues, we begin to realize how immense is the influence of the system on the establishment of disease. It would appear, in short, that the deleterious influences which have been at work have so affected the capillary system that its vital activities are depressed, and the comparatively large space of the capillary tissue becomes a catchment area in which a proportion of the fluid blood is prevented from passing into the general circulation.

There is, in fact, evidence to show that the fall in arterial blood-pressure, which is such a distinctive feature of surgical shock, is due to a reduction of the volume of blood in active circulation, and that this diminution in volume is the result of the withdrawal from active circulation of a proportion of blood which stagnates in the capillary circulation.

2. **The Respiratory Disturbances.**—The distinctive character of the respiration in shock is that of a superficial, rapid type, with occasional deep sighs and at intervals a quick respiratory flutter. It may be recalled that Henderson in his acapnia theory claimed that the respiratory change was a primary factor in shock, because an extreme pulmonary ventilation so diminished the CO_2 content of the blood as to produce what he termed an 'acapnia' which resulted in the circulatory and other phenomena of shock. If this view is correct, the body in the early stages of shock should show a diminished amount of CO_2, but Janeway and Ewing[25] have proved that the CO_2 content is not reduced, and this observation has been confirmed by others.

It must therefore be accepted that the respiratory changes are not primary, but are secondary to the influence of other factors. The first of these factors exists in the low blood-pressure, and therefore in the diminished O_2-carrying power of the blood, which we have described in connection with the circulatory disturbances. A reduction in the amount of O_2 provided by the blood for the central nervous system results in an irritability of the various nerve-cells and centres, which is reflected in the rapid respiration of shock.

The second factor which may explain the respiratory changes is a natural sequence of the first. Owing to the ineffective nature of the shallow breathing which results from the imperfect supply of O_2 there is an abnormally high CO_2 content of the blood, and at the same time there is, for reasons which are discussed later, a reduction of the body alkali—in fact, the combination of changes may be spoken of as an increase of the hydrogen-ion content. Now Haldane and Priestley[26] have shown how extraordinarily sensitive the respiratory centre is to an increase of the hydrogen-ion content, and the type of respiration which results is of a rapid and deep character. In the later stages of shock the shallow respiratory type of the early stage is replaced by intervals of a rapid, deep, and gasping character.

The third influence which may effect the respiratory change is of a more hypothetical nature; it is the exaggerated Herring-Breuer reflex described by Haldane[27]. In normal respiration, as the lungs are being stretched by the action of the respiratory muscles, certain nerve-endings or 'receptors' are stimulated, and it is this stimulation which inhibits inspiration and excites expiration. Under certain conditions the inhibitory stimulus occurs early in the course of inspiration, and a rapid shallow respiration naturally results. Surgical shock, in common with hæmorrhage, appears to have the effect of so altering the reflex.

We may therefore summarize the respiratory changes as follows: The characteristic respiration of shock is of a rapid shallow character; in the later stages it becomes deep and rapid; and the factors which induce these changes are the low arterial pressure with its associated decrease of the O_2-carrying power of the blood, possibly an alteration of the Herring-Breuer reflex, and in the later stages of shock an increase of the hydrogen-ion content of the blood, with direct stimulation of the respiratory centre.

3. **The Motor Disturbances.**—An increasing motor weakness extending into muscular apathy is distinctive of the 'shocked' condition. It has been suggested that these changes result from repeated sensory stimuli, which, being converted in the central nervous system into motor impulses, lead eventually to physiological block in the motor tract. Sherrington[28] has disproved this possibility. He has shown that, if stimuli are repeated so as to produce a block in the afferent paths, and therefore a failure in the reflex, the reflex is at once produced if a new afferent path is chosen. The motor mechanism is less affected than the sensory in repeated stimulation.

The explanation of the motor changes in shock is to be found in the low arterial pressure. Gruber has shown that when the systolic pressure is reduced below 90 mm., the muscles as contractive organs become less capable of work, and the whole central nervous system shares in an impaired nutrition secondary to the lowered blood-pressure; the afferent tracts and sensory cells, the

synapse, motor cells and tracts are equally affected. It is therefore not surprising that in the victim of shock there is a general relaxation of the body musculature, irregular and feeble movements, and a slowing and weakening of central nervous functions.

These remarks are intended to apply more especially to striped or voluntary muscle; involuntary or non-striped muscle, such as the alimentary canal, is also inhibited, but its inhibition has a different explanation from that of voluntary muscle. In the case of the non-striped muscle the inhibition would appear to be due to activity of the sympathetic nervous system.

4. **The Sensory Disturbances.** — Diminished sensibility to stimulation is one of the most striking clinical evidences of shock. Sherrington offers the explanation that the afferent impulses are blocked at the junction or synapse between the afferent neurones and the neurones which lie wholly within the central nervous system. The phenomenon of 'blocking' he accounts for as being due to an increase of the natural resistance at the synapse to such a degree that the impulses fail to pass. When an explanation is demanded as to why there should be increased synaptic resistance associated with shock, we find it in Porter's experiments on the effect of low arterial pressure. Porter studied the effect of low blood-pressure on the minimal strength of the stimulus required to evoke a reflex in the spinal cord, and he found that with a uniform level of arterial pressure the threshold stimulus for the reflex remains practically uniform. If the blood-pressure is lowered the threshold rises, synaptic resistance increases, and a greater strength of stimulus is required to evoke a response. In Porter's experiments the minimal stimulus rose from 40 to 110 units as a result of lowering the blood-pressure. Whether the question of lowered arterial pressure is read as a diminished amount of O_2 or as an increased amount of CO_2 does not appear to matter, for both conditions have the effect of raising the synaptic threshold.

There is, however, another explanation of the diminished sensibility in shock; in connection with motor disturbances we have drawn attention to Sherrington's experiments, in which he demonstrated that, apart from considerations of blood-pressure, repeated afferent stimuli eventually give rise to a sensory block by producing an increased synaptic resistance.

The evidence which we possess, therefore, indicates that the sensory disturbances of shock are the result of an increased synaptic resistance, which in its turn proceeds from excessive stimulation along afferent tracts and from a continued low blood-pressure.

The Causes of the Production of the Low Blood-pressure.—It will be observed that running throughout the various clinical manifestations of shock, whether circulatory, respiratory, sensory, or motor, there is the common thread of a low blood-pressure. Not only does this state explain in large measure the various clinical evidences, but it is the starting-point of a vicious circle to which allusion will be made later. It is therefore important that we should consider any evidence which we have in explanation of the low arterial pressure.

1. *Nervous Causes.*—Of the exact way in which nervous influences act upon the blood-pressure we know very little, but in different types of individual

and under varying conditions remarkable alterations of blood-pressure may be recorded. In certain individuals a low blood-pressure is a normal state, and in most of us the reactionary period which follows an interval of strain is associated with some degree of hypotension. We have noticed that the blood-pressure of a soldier in the trenches recorded 140 mm. (systolic), while the same individual in rest billets registered 100 mm. (systolic). Underlying this fact there is the suggestion that the state of hypotension which is a natural sequel to any period of strain is a time of danger from the point of view of the inauguration of shock. There are many obvious practical applications of this point in relation to surgical operations, etc.

2. *The Influence of the Absorption of Toxic Products from Damaged or Infected Tissues.*—Sir Cuthbert Wallace has emphasized the increased liability to shock when large muscular masses are cut. He contrasted the degree of shock after interscapulo-thoracic amputation with that after amputation at the hip-joint, the degree being considerably greater in the latter because of the relatively large amount of muscle which is divided. The experience of the war confirmed this view, and it also drew attention to the frequent association of severe shock with compound fracture of the thigh and multiple wounds. Such observations as these have been made the basis of experimental investigations by Bayliss and Cannon.[29] They found that within an hour after producing a compound fracture of the femur in an anæsthetized cat, the fracture being accompanied by bruising of the large flexor muscles of the thigh, the animal showed signs similar to those which one associates with surgical shock. The blood-pressure gradually fell, pulse-rate and respiration increased, the blood showed signs of concentration, and the animal finally succumbed.

The next stage in the experiment was to isolate the limb from the central nervous system and subsequently to traumatize it in the way described. The sequel was exactly similar, and this result definitely excluded the possibility that harmful efferent stimuli from the injured limb were responsible for the symptoms.

When, however, the third stage of this experiment was carried out, and the return of blood from the damaged limb was prevented by means of small clips, there was no resulting fall of blood-pressure; but as soon as the clips were removed and the returning blood reached the body, the blood-pressure fell. We must assume that the muscle destruction resulted in the liberation of a tissue-poison which, circulating in the blood, produced the fall in blood-pressure.

The question naturally arises as to how the tissue-poison acts in producing this effect. Vincent and Sheen[30] found that extracts of muscle have a specific effect in producing vasodilation, and Dale and Richards[31] showed that histamine dilates the capillaries; they suggested that substances of similar action are produced by injury to tissues. The result of a widespread capillary dilatation would be the 'side-tracking' of a considerable amount of blood into them, and the loss of this amount of blood to the general circulation would act very similarly to a hæmorrhage by producing a lowering of the blood-pressure.

3. *The Influence of Cold.*—Prolonged exposure of the body to cold has an undoubted effect in lowering the blood-pressure, and its influence is probably

greatest when the tension has begun to fall from the effect of some other deleterious influence, in which case it acts as an aggravating feature in further reducing the arterial pressure. It would seem that the cooling of the body surface results in a retardation of the blood-flow through the superficial capillaries—this directly leads to a diminished supply of blood to other regions of the body, the lowering of the temperature increases the viscosity of the blood, and thereby the blood-flow in the capillaries is still further retarded. The influence of this combination of features invariably leads to a progressive fall in blood-pressure.

4. *The Possible Influence of the Internal Secretions.*—The theory was at one time advanced that exhaustion of the suprarenal bodies played an important part in reducing the blood-pressure and so inaugurating the cycle of shock. It was suggested that strong emotional influences either led to a primary deficiency or produced a temporarily higher secretion and a resulting hypo-secretion. Our evidence on this point is not conclusive. Cannon[32] and Elliot[33] have been able to demonstrate the presence of adrenalin in the blood of wounded men—in individuals, therefore, who, it may be supposed, suffered in some degree from shock. Bedford confirmed a similar finding in experimental shock. It is interesting to notice that the experimental injection of large doses of adrenalin produces a shock-like condition with an associated fall in blood-pressure.

It is possible that the suprarenal secretion, perhaps in common with the secretion of other ductless glands, may exert an influence upon the introductory phenomenon of shock, but any influence which they may possess is more likely to be of a secondary nature, and therefore demonstrable when metabolism is seriously interfered with.

5. *The Influence of Anæsthesia.*—The administration of an anæsthetic is associated in the early stages of anæsthesia with a rise of blood-pressure, but this is soon succeeded by a gradual fall. At first the decline is very gradual, but after the anæsthetic has been in use for a certain period of time the fall becomes more rapid, and this state of hypotension may well be, and frequently is, the starting-point of a grave post-operative shock; the danger is all the more real because such influences as tissue injury, cold, hæmorrhage, and emotion may coincidently be exerting their influence. Of the various anæsthetics, chloroform appears to be the most dangerous in this respect.

6. *The Influences of Hæmorrhage and Sepsis.*—No elaboration of these influences is necessary—the effect of hæmorrhage is self-evident. There appears to be a definite limit up to which a pressure compensation is possible, but when this point is reached the fall is rapid and maintained. We perhaps attach insufficient importance to the influence of sepsis on the blood-pressure. Any general infection, whether a toxæmia or a septicæmia, is associated with hypotension, and it would seem that the anærobic infections are especially harmful.

The Sequence of Events after a Low Blood-pressure has been Established.—From whatever cause the lowering of the blood-pressure has proceeded, the effect of the change is to set in action a series of events which ultimately leads to a derangement of the various processes of body metabolism.

1. *Deficient Oxygenation of the Body Tissues.*—A continued low blood-pressure necessarily implies a diminished O_2 supply to the various body tissues, and such an unnatural state of affairs is reflected in the institution of what one may term a physiological pathology of the cells and their products. The cells individually may be structurally damaged, while the products of their activity are in a state of incomplete metabolism, and this is frequently synonymous with a condition of toxicity.

2. *Capillary Stasis.*—The effect of a persistently low blood-pressure is to encourage a general capillary stasis, and the first stage of a vicious circle is thus begun, for capillary stasis results in diminished oxygenation of the tissues, while the diminished oxygenation still further aggravates the capillary delay, and it is an obvious sequence that a further fall of blood-pressure will ensue.

3. *The Development of Acidosis.*—Normal blood plasma contains a certain percentage of sodium bicarbonate, and this constitutes the alkali reserve of the blood and one of the alkali reserves of the body. A reduction of this alkali reserve is spoken of as an 'acidosis' (L. J. Henderson, Van Slyke). The term is also used in another connection which it is important to explain. The bicarbonate of the blood plasma contains a weak acid in the form of dissolved CO_2 (H_2CO_3), and the relationship between the acid and the alkali is expressed in terms of what has been called the hydrogen-ion concentration. If the bicarbonate ($NaHCO_3$) decreases while the CO_2 increases or remains constant, it is said that the hydrogen-ion concentration rises (acidosis); if the CO_2 decreases while the $NaHCO_3$ remains constant or increases, the hydrogen-ion concentration falls; if both vary together so that the proportion to one another remains constant, the hydrogen-ion concentration is unchanged. There can be no doubt that in shock an acidosis develops, and it would seem that at first it is in the sense of a reduction of the bicarbonate content of the plasma, while at a later stage there is an actual increase of the hydrogen-ion concentration.

The question has arisen as to whether the acidosis, the existence of which is beyond dispute, should be regarded as a determining factor in the cycle of shock symptoms (in other words, an essential cause), or whether it is a secondary result of a progressive circulatory deficiency. The question is best answered in certain of the conclusions which have been arrived at in Report No. 7 of the Shock Committee (Medical Research Council).

1. Acidosis in the sense of a simple reduction of the bicarbonate of the blood plasma is not the *cause* of shock or even an important factor in its production.

2. A progressive uncompensated fall of the alkali reserve is the result of an inadequate oxygen supply to the tissues.

3. Oxidation of the tissues is more easily rendered inadequate by defective circulation through the capillaries than by a reduction of the O_2-carrying power of the blood.

4. The fall of the alkali reserve is a *symptom* of a deficient capillary circulation and not a *cause* of such.

5. To some extent the fall of the alkali reserve in its early stages is a protective measure, its protective action being through stimulation of the

bulbar centre, but in the later stages, as the hydrogen-ion concentration increases, the protective action disappears.

This important, and in some respects vital, metabolic derangement of shock is, therefore, distinctly traceable to a capillary stasis, and this in its turn is dependent, as we have shown, upon a low blood-pressure and its concomitant factors.

GENERAL CONCLUSIONS AS TO THE NATURE OF SURGICAL SHOCK.

The essential underlying factor in the production of the 'shocked' condition is a prolonged and progressive fall in blood-pressure. The causes which inaugurate the original fall are various; some are nervous, some are clinical, in many instances there is a combination of causes; hæmorrhage, sepsis, and the absorption of toxic products from injured tissues are collateral and sustaining factors of great influence. With the establishment of a persistently low blood-pressure something of the nature of a vicious circle comes into play, the prolonged hypotension leads to imperfect oxygenation of the body tissues, and to a capillary stasis; the capillary stasis reduces the amount of blood in active circulation, and the imperfect oxygenation of the tissues results in the formation of various toxic products from imperfect tissue metabolism. These influences collectively further reduce the blood-pressure, the vicious circle is maintained, and the tendency is for it to continue to a fatal issue unless some link in the chain is broken and the hypotension error is overcome.

SOME CONSIDERATIONS OF TREATMENT.

In view of the full consideration which has been given to the clinical aspects of the problem, it is only possible to summarize the more important details of treatment. As far as possible the considerations are arranged under individual headings.

1. **Estimate the Degree of Shock which is Present.**—Considerations of prognosis and subsequent treatment make it essential that we possess some knowledge of the degree of shock which is present. The simple clinical observation of the patient's appearance and pulse-rate affords a certain amount of information, but this is unreliable, and the only exact estimation which we have is by recording the systolic blood-pressure; a systolic pressure which registers 90 mm. or less indicates such a degree of shock that immediate restorative measures are necessary.

2. **Exclude the Possibility of Hæmorrhage or Sepsis simulating True Shock.**—It may seem unnecessary to record this piece of advice, but the error is frequently made of mistaking the evidence of hæmorrhage or sepsis for true surgical shock. To concentrate upon the treatment of shock while these independent influences are at work is to court inevitable failure.

3. **The Importance of Warmth.**—If we appreciate the importance of capillary stasis in the pathology of shock, we are in a position to realize how vital it is to ensure warmth to the individual who is exposed to the possibility of shock. The deleterious influence of cold is especially dangerous when the individual is unconscious or under the influence of a general anæsthetic. We have seen an individual exposed to such an amount of chill during a surgical

operation that at the conclusion of the operation the temperature of the interior of the thigh muscles was 94°. The influence of such a low body temperature in the development of shock must be enormous.

4. **The Importance of Fluid.**—If our estimation of the pathology of shock is correct, it is dangerous to limit in any degree the administration of fluids. A high fluid consumption has an influence in maintaining blood-pressure, it tends to diminish oligæmia, and therefore capillary stasis, while its certain benefits are the dilution and removal of the deleterious imperfect metabolic products. If the oral administration of fluid is for any reason impossible, the other avenues are employed. In view of the importance of the reduction of the blood alkali in shock, drachm doses of sodium bicarbonate should be given at intervals in combination with the fluid.

5. **Food.**—Starvation is to be avoided in both the prevention and the actual treatment of shock. Food should be allowed if there is an appetite for it, unless some special contra-indication exists, and foods of high carbohydrate content are essential.

6. **Sleep and Rest.**—There can be no doubt regarding the wonderful restorative benefits of sleep. A natural sleep is, of course, the best, and therefore the patient should be kept in comfort and quietness, and shaded from strong light.

In many cases sleep must be induced, and this is best accomplished by morphia. It is a debatable point to what extent the administration of this drug may be pushed; Crile advocates repeated doses until the respirations are reduced to twelve per minute, but it has been maintained that such reduced respirations increase the risk of acidosis, and the consensus of opinion is in favour of the administration of morphia to a point when pain and restlessness are relieved, and no further. The fact must be kept in mind that, with a rise of blood-pressure, a natural sleep often follows.

7. **Drugs.**—Adrenalin and strychnine, two former standbys in the treatment of shock, are now condemned as useless and possibly dangerous. Pituitary extract may produce a temporary benefit from its stimulating effect on the cardiovascular system, but there is no continued advantage from its use, and repetition of the drug is dangerous. Alcohol has no real stimulating effect, and the only excuse for its administration will be its use as a body food. Digitalis and camphor are useful as temporary stimulants; oxygen should be administered if there is any evidence of cyanosis, it also relieves restlessness and the air-hunger of the late stages of shock; glucose and bicarbonate of soda are of value if there is evidence that an acidosis is impending or has developed.

8. **Transfusion.**—The essential feature in the development of shock being the fall in blood-pressure, various remedies are directed towards raising it, and naturally an intravenous infusion of fluid is the most rapid and effective method at our disposal. The question arises as to the type of fluid which should be used.

a. Saline Solutions.—Normal saline has been for many years the fluid in most common use, but we now recognize that its beneficial effect is only a transient one. Its intravenous injection in large quantities produces dilution of the blood and an increase in its total volume; the kidneys, the skin, and

the lymph channels excrete the excess of fluid; there is profuse perspiration; and presently the blood is actually less in bulk and more concentrated than before. Its benefit is therefore a very temporary one, and eventually its use may do more harm than good. Similar remarks apply to Ringer's solution and its various modifications.

b. Colloidal Solutions.—In Bayliss's gum-saline solution (6 per cent gum acacia in 0·9 per cent sodium chloride) we have a fluid for intravenous injection which has proved of enormous value in practical use. In his most recent publications on the subject, Bayliss[34] speaks of it as follows:—

> The most important factor in the treatment of wound shock is the ensuring of an adequate supply of blood (that is, of oxygen) to vital organs, especially to the nerve centres. This is most easily done by the intravenous injection of a 6 per cent solution of gum acacia in 0·9 per cent sodium chloride in order to increase the volume of blood in circulation and to raise the arterial pressure.

The technique of transfusion and infusion does not concern us; it is only necessary to say that one pint of the solution should be given to begin with, and it ought to be given as early as possible after shock has begun to develop. If within half an hour only partial benefit is apparent, a further injection may be made. It is advisable to give the infusion slowly, fifteen minutes being required for the introduction of a pint. The solution should be warmed to blood heat.

Erlanger and Gasser advise the use of a 25 per cent gum in 18 per cent dextrin. This mixture results in a very viscid solution, and clinically the results have not been as good as those with Bayliss's solution.

c. Blood Transfusion.—In cases of shock where there has been the complicating factor of severe hæmorrhage, the transfusion of human blood gives most excellent results. The method may be used in shock apart from hæmorrhage, but it is in the cases where there has been loss of blood that the results are most striking. The majority of surgeons are agreed that the citrate method of transfusion is the safest and most reliable.

d. Preserved Blood-corpuscles.—Based upon the researches of Abel, Rous, and Turner,[35] the injection of blood-corpuscles preserved in a citrate-dextrin solution may be employed. The solution may be kept in ice for as long as three weeks, and the results obtained have been encouraging.

The Influences of General Anæsthesia and Surgical Operation upon Shock.—If, during the progress of a surgical operation of any magnitude, certain investigations are made, it will be found that three changes have appeared:—

1. There is a lowering of the systolic blood-pressure.
2. Examination with the hæmatocrit shows a gradually increasing concentration of the blood.
3. There is a reduction of the alkali content of the plasma.

In fact, during the progress of the operation there has been the inauguration of the three processes which have such an important influence upon the institution of the shocked condition. In the large proportion of cases these various changes are so slight that little clinical evidence of their presence is apparent, but none the less they are the basis of shock, and under unfavourable

conditions they may assume dangerous proportions. If the development of these features is to be kept within the limits of safety (their complete avoidance is impossible), certain precautionary measures are necessary, and these may be summarized as follows :—

1. Operation on a case which shows persistent low blood-pressure should be delayed, if possible, until means have been taken to raise the blood-pressure.

2. The operative procedure should be as short as is consistent with thoroughness.

3. The operation should be carried out with the least possible interference and trauma. Every effort should be made to avoid unnecessary loss of blood.

4. 'Chilling' of the patient before, during, or after the operation must be avoided.

5. If it is possible to exercise a choice of anæsthetic, nitrous oxide and oxygen should be chosen.

6. If simple restorative measures have failed to raise the blood-pressure before operation, it ought to be raised artificially by the intravenous infusion of human blood or of 1 pint of 6 per cent gum–acacia solution in normal saline.

7. If examination of the blood shows that a condition of acidosis is present before operation, a reserve of alkali should be built up by the intravenous infusion of 1 pint of 4 per cent solution of sodium bicarbonate.

BIBLIOGRAPHY.

[1] CRILE, *Surgical Shock*, Philadelphia : 1899. *Blood-pressure in Surgery*, London : 1903. "The Kinetic Theory of Shock and its Prevention through Anoci-association", *Lancet*, 1913, i, 7. *The Origin and Nature of the Emotions*, Philadelphia : 1915, 227.

[2] MUMMERY, "The Hunterian Lectures on the Physiology and Treatment of Surgical Shock and Collapse", *Lancet*, 1905, i, 696, 776, 846.

[3] MALCOLM, "A Lecture on the Condition of the Blood-vessels during Shock", *Lancet*, 1905, ii, 573, 618, 737, 922.

[4] SEELIG and LYON, "The Condition of the Peripheral Blood-vessels in Shock", *Jour. Amer. Med. Assoc.*, 1909, lii, 45.

[5] PORTER and QUINLEY, "Vasomotor Relations", *Boston Med. and Surg. Jour.*, 1908, clviii, 73.

[6] HENDERSON, Y., "Acapnia and Shock, Failure of the Circulation", *Amer. Jour, Physiol.*, 1910–11, xxvii, 152. "Shock" (Int. Med. Monographs, 1913), *Amer. Jour. Physiol.*, 1908, xxi, 126 ; 1909, xxiii, 345 ; xxiv, 66 ; 1910, xxv, 385 ; xxvi, 260 ; xxvii, 152 ; 1911, xxviii, 275.

[7] SHERRINGTON, C. S., and COPEMAN, S. M., "Variations Experimentally Produced in the Specific Gravity of the Blood", *Jour. of Physiol.*, 1893, xiv, 52.

[8] BOISE, "The Nature of Shock", *Amer. Jour. Obst.*, 1907, lv, 1, 95.

[9] MELTZER, "The Nature of Shock", *Arch. of Internal Med.*, 1908, i, 571.

[10] KINNAMAN, "An Explanation of the Phenomena of Shock based upon a Disturbance of Thermogenic Function", *Internat. Jour. Surg.*, 1904, xvii, 378.

[11] JABOULAY, "L'oxyhemoglobine dans le Shock", *Lyon méd.*, 1904, ciii, 519.

[12] BAINBRIDGE and PARKINSON, "Morbid Anatomy of the Suprarenal Glands", *Lancet*, 1907, i, 1296.

[13] SCHUR and WEISEL, "Ueber das Verhalten des chromaffinen Gewebes bei der Narkose", *Wien. klin. Woch.*, 1908, xxi, 247.

[14] VALE, "Concerning Shock, with a Contribution to its Pathology", *Med. Record*, 1904, lxvi, 325.

[15] BISSELL, W. W., "Concerning Shock, with a Contribution to its Pathology", *Surg. Gynecol. and Obst.*, 1917, xxv, 8.

[16] CANNON, W. B., *Concerning Shock, with a Contribution to its Pathology* (Shattock Lecture, 1917).

[17] MANN, "The Peripheral Origin of Surgical Shock", *Johns Hop. Hosp. Bull.*, 1914, xxv, 205.
[18] MANN, "Shock and Hæmorrhage", *Surg. Gynecol. and Obst.*, 1915, xxi, 430.
[19] SEELIG and JOSEPH, "On the Tonus of the Vasomotor Centre in Shock", *Proc. Soc. Exper. Biol. and Med.*, 1914, xii, 49.
[20] GUTHRIE, "Observations on Shock", *Amer. Jour. Physiol.*, 1918, xlv, 544.
[21] CRILE and DOLLEY, "The Pathological Cytology of Surgical Shock", *Jour. Med. Research*, 1910, xxii, 331.
[22] KEITH, "Blood-volume Changes in Wound Shock and Primary Hæmorrhage", *M.R.C. Spec. Rep. Ser.*, No. 27, London: 1919.
[23] ROBERTSON and BOCK, "Blood-volume Changes in Shock", *Ibid.*, No. 25, London: 1919.
[24] KROGH, "Blood-volume Changes in Shock", *Jour. of Physiol.*, 1919–20, iii.
[25] JANEWAY and EWING, "The Nature of Shock, its Relation to Acapnia and to Changes in the Circulation of the Blood and to Exhaustion of the Nerve Centres", *Ann. of Surg.*, 1914, lix, 158.
[26] HALDANE and PRIESTLEY, "The Regulation of the Lung Ventilation", *Jour. of Physiol.*, 1905, xxxii, 225.
[27] HALDANE, MEAKINS, and PRIESTLEY, "The Reflex Restriction of Respiration after Gas Poisoning", *M.R.C. Chem. War Med. Comm. Report*, No. 5, London: 1918.
[28] SHERRINGTON, "Note on the Knee-jerk and the Correlation of Action of Antagonistic Muscles", *Proc. Roy. Soc., Lond.*, 1893, lii, 556.
[29] BAYLISS, *Intravenous Injection in Wound Shock* (Oliver Sharpey Lectures, 1918), London: 1918.
[30] VINCENT, S., and SHEEN, "The Effects of Intravascular Injections of Extracts of Animal Tissues", *Jour. of Physiol.*, 1903, xxix, 242.
[31] DALE and RICHARDS, "The Vasodilator Action of Histamine and of some other Substances", *Jour. of Physiol.*, 1918–19, lii, 110.
[32] CANNON, *Bodily Changes in Pain, Hunger, Fear, and Rage*, New York: 1916.
[33] ELLIOTT, "The Control of the Suprarenal Glands by the Splanchnic Nerves", *Jour. of Physiol.*, 1912, xliv, 374.
[34] BAYLISS, *loc. sup. cit.*
[35] ABEL, ROUS, and TURNER, *Jour. Pharmacol. and Exper. Therap.*, 1914, v. 625; *Jour. Amer. Med. Assoc.*, 1918, iv, 219.

REPORT OF THE DISCUSSION ON OPERATION SHOCK

AT THE INTERNATIONAL SURGICAL CONGRESS, LONDON, JULY, 1923.

THE discussion on operation shock was opened by Crile, of Cleveland, Ohio, U.S.A. The paper in which the subject was introduced was an ingenious exposition of what he termed " the electro-chemical interpretation of shock and exhaustion ". The living body was visualized as a complex and elaborated combination of electro-chemical elements, and, as the body is built up of an infinite number of individual cells, correspondingly great is the combination of electro-chemical arrangements, because each cell of the body possesses its own individual and peculiar electrical arrangements. The electric energy which the cell displays is dependent for its source upon the process of oxidation, and the hypothesis was presented that the cell nucleus is electrically positive while the cytoplasm is negative. Crile expressed his appreciation of the point in the following words :—

> " Cells have the power of oxidation only as long as there is a difference in the potential between the nucleus and the cytoplasm, and a difference in potential is maintained only as long as there is oxidation."

The idea which the sequence is intended to convey may efficiently, and perhaps more accurately, be expressed by the accepted truism that efficient oxidation is essential for the health and well-being of the individual cell.

Crile proceeded to elaborate the fact that for efficient oxidation two things are essential—oxygen and water. The oxygen is necessary for the combustion which the process implies; the water is the vehicle by which the O_2 is brought into contact with the cell, while it carries away the acids which result from the process of oxidation ; in fact, it is the vehicle of the restoration of the acid-alkali balance of the body. As the process of oxidation reaches its highest level in the nucleus of the cell, any electrical current which exist will flow from the point of higher potential (the nucleus) to that of the lower (the cytoplasm); from this idea the further elaboration was made that a somewhat corresponding difference in potential exists between individual organs of the body ; the brain is regarded as the site of the highest potential—the positive pole—the liver the negative pole, the nerves the connecting wires, and the salts in solution the electrolytic fluid in which the electro-chemical mechanism is immersed. In such an arrangement it is assumed that, since electricity flows from a higher to a lower potential, and since oxidation is highest in the brain, oxidation electric waves pass down the nerves from the area of higher potential within the brain to the areas of lower potential in the muscles and glands, and since the liver has the lowest rate of oxidation—hence the lowest potential—the current would finally reach that area, whence it would return by the electrolytic system to the brain, thus completing the

circuit. Such may be said to be the conception of vitality as imagined by Crile.

The author reviewed the more recent work which has been attempted in connection with the etiology of surgical shock, and his conclusion was that, while there is uniformity of opinion in regard to the end-results of shock—alteration in blood-pressure, diminution in the alkali reserve, changes in the H-ion concentration of the blood—in no instance has any real knowledge been brought forward which throws light upon the actual cause of shock. It would seem as though every known method of physiological investigation has been brought forward without avail. In face of this, Crile and his co-workers have turned to their conception of the electro-chemical arrangements of the body, and in disturbance of these they believe they have found the explanation of the phenomena of shock and exhaustion.

In shock, in exhaustion, and in other associated phenomena it is believed that three changes are apparent :—

1. Changes in the electrical variation and conductivity of the tissues.
2. Changes in histological structure, as revealed by certain methods of staining.
3. Changes in functional activity, as evidenced by variations in temperature dependent upon alteration in oxidation, and demonstrable by the use of the thermocouples.

The change which would appear to be the starting-point in the combination of features collectively associated with shock is a lowering of the difference between potentials in individual cells and relatively between potentials of different body structures. Such a lowering of the potential ratio is probably dependent upon an error in the process of oxidation, in which case the oxidation failure is more truly the primary cause of the disturbance, and, as the brain is the most important site of oxidation, and therefore the chief source of electrical energy, interference with its functions results in secondary changes throughout the entire body. In consequence of the change in electrical variation there are the resulting errors of depression of functional activity, and demonstrable histological changes.

Crile would define shock as the ultimate result of a deepening degree of exhaustion, the exhaustion being primarily " the result of a diminution of the difference in potential between the poles of the organism due to a decrease in the potential of the brain, which in turn results from a decreased difference in potential in its constituent cells ". " This conception explains the identity of the phenomena of exhaustion and the progressive degrees of exhaustion to shock." " When the difference in potential reaches zero . . . the organism is dead."

The paper concluded with a clinical application of the conception that man is an electro-chemical mechanism, and the following well-accepted principles were urged :—

1. The organism needs an abundant supply of fresh water.
2. An abundant supply of oxygen must be delivered to the cells.
3. The permeability of the selective semi-permeable membranes must be maintained within a normal range.

4. Both the local and the general temperature of the body must be kept at or near the normal.
5. An abundance of mental and physical rest and an abundance of sleep are essential.
6. The physical structure of the cells must not be impaired by the indirect effects of the trauma of the operation or by the anæsthetic.

By the practical application of these principles the two essential factors (O_2 and water) in the maintenance of the integrity of the electro-chemical system are assured, provided recovery is anatomically possible and the disintegration of the cells has not progressed to the early stages of inevitable dissolution; that is, provided the acid-alkali balance—the difference in potential—within the cells is maintained or restored, and their internal respiration is protected.

The practical application of the above principles is achieved—especially in bad-risk cases—by the following measures :—

1. Nitrous oxide analgesia (not anæsthesia) in combination with local anæsthesia.

2. The two-stage operation, if it is found that a primary interference is being badly tolerated.

3. Water is administered by every possible route in order to ensure sufficient hydration of the cells; 3000 c.c. is routinely given by hypodermoclysis by Bartlett's method.

4. Oxygenation of the cells is promoted by the transfusion of whole blood, before, during, and after operation, according to indication.

5. Digitalis is administered routinely in all cases in which the myocardium is impaired, in order to ensure the maintenance of an adequate circulation.

6. Rest and sleep are promoted by attention to the environment and by narcotics, except in cases in which jaundice exists; in these latter cases the already depressed liver-cells would be further injured by the use of morphia.

7. In abdominal cases moist hot packs are applied immediately after operation " for the support of the liver-cells ".

If justification of these methods is required, it is found in the mortality statistics which Crile quoted : " During the period from 1919 to the present date (April 1, 1923) the mortality-rate of the surgical service at Lakeside Hospital has fallen from 2·4 to 1·2 per cent; the mortality-rate of the last 500 ligations has been 0·8 per cent, and of the last 500 thyroidectomies for exophthalmic goitre 0·6 per cent ".

The discussion was continued by Quénu, Duval, and Mocquot (Paris), who in collaboration contributed a paper upon a clinical study of shock. The conclusions at which they arrived may be summarized as follows :—

A. Various theories which attempt to explain shock as arising from a primary derangement of the nervous system are false, and such theories fail to tally with the results of clinical observation.

B. They believe :—

1. That they have been able to demonstrate a close relationship between the destruction of large tissue masses and the development of surgical shock.

2. That microbic infection plays no part in the primary development of shock.

3. That the condition which inaugurates the train of shock symptoms is actually the wounding of the tissue, and this apart from any question of the influence of the nervous system.

4. That the early excision of the wound focus may prevent the development of shock, or at least so improve the evidences of it that recovery follows in the most desperate cases.

5. That the clinical observations and results are in support of the hypothesis that shock owes its primary development to the absorption of harmful products from a wound or area of tissue destruction.

The reporters proceeded to discuss the etiology of shock as they understood it. They recalled the well-recognized influence of crushing or bruising of the tissues, they showed that severe injury unaccompanied by tissue destruction (as, for example, in avulsion of a limb) may be unaccompanied by shock, and they further discussed the secondary influence of cold, hæmorrhage, and fatigue.

From a clinical basis they proposed to subdivide shock into three groups—immediate, primary, and secondary. Immediate shock is rare, and in war work at least it was difficult to separate examples of true immediate shock from somewhat similar conditions which owed their development to hæmorrhage or poison gas. The stage of primary shock was defined as that which exists up to the time when organismal infection may first become evident; it is probably due to the absorption of noxious products from the injured tissue of the wounded part. The evidences may become apparent within thirty minutes of receipt of the wound, and under special conditions of temperament or fatigue its manifestations may be even more rapid. The stage of secondary shock was recognized as practically synonymous with that of septic absorption from the infected wound.

The authors described a series of investigations which they had carried out in connection with the clinical manifestation of the so-called 'primary shock'. A fall of temperature was considered to be the most distinctive feature, and the inference was made that such a derangement of temperature was the direct result of the absorption of the injured tissue products. Lowering of the blood-pressure was the second distinctive feature quoted. An account was given of the blood investigation; it was recorded that during this stage of shock there is an increase of the various nitrogenous substances of the blood, and especially of the residual nitrogen (a diminution of the alkali reserve). Examination of the urine with a view to explaining the nitrogen blood changes revealed changes of considerable importance, the principal being a fall in the urea output and a diminution in the urine bulk.

The clinical progress of the shocked condition follows one of two lines—the symptoms may gradually deepen, those of septic absorption succeeding those of primary shock until a fatal issue develops; or, on the other hand, improvement may appear, suddenly or gradually, and synchronous with the improvement there is a urinary 'crisis', in which the fluid output is raised and the urea content increased.

A portion of the paper was devoted to consideration of prognosis. Evidences of temperature and of blood-pressure were not considered of great value, but importance was attached to the results of the blood and urine examination, especially in regard to the relative urea content of each.

The paper concluded with an account of the authors' experience in the treatment of shock. In view of the importance which they paid to the influence of toxic absorption, it was not surprising to find that the suppression of such absorption formed the basis of their line of treatment. Prophylactic measures were urged, and these included the maintenance of the body heat, the immobilization of the injured limb, the arrest of hæmorrhage, and the employment of a tourniquet, partly to prevent hæmorrhage, but, even more important, to minimize the absorption of toxic products from the injured area. With this last consideration in mind, the use of antitoxic sera was recommended, and also the 'fixation' of the injured tissues by such chemicals as formalin.

Symptomatic treatment included the increasing of the body temperature, and the raising of the blood-pressure by intravenous injection of blood, gum, or saline. The causal treatment of shock necessarily embodied early removal of the focus from which the toxic absorption proceeded—amputation when a limb was irreparably damaged, excision of suitable wounds.

Fraser (Edinburgh) discussed the problem of shock from a clinicopathological aspect—the paper is reported fully in the present issue.

In view of the fact that a low blood-pressure is the most distinctive and the most constant evidence of the shocked condition, an attempt was made to explain its occurrence. It was believed to depend upon a reduction of the blood volume in active circulation, and the explanation of the reduction was to be found in a capillary stagnation. Special attention was paid to the hitherto unappreciated importance of the capillary system in the development of shock and possibly of other types of cardiovascular disease. The various circulatory, respiratory, motor, and sensory manifestations of shock were traced to the essential influence of the hypotension. The paper included an account of the various prophylactic and active measures in the treatment of shock.

Pauchet (Paris) contributed a communication upon the results which he had obtained in the treatment of shock by the transfusion of pure oxygenated blood. He considered such a method infinitely preferable to that of the citrated blood transfusion. The donor's venous blood is passed into a vessel containing oxygen, and it is then shaken up until it has acquired the characteristics of bright arterial blood. The special advantages claimed for this method include :—

1. The immediate increase in blood-pressure.

2. The maintenance of the high pressure owing to the fact that the blood does not readily pass through the vessel walls.

3. The stimulating effect of the oxygen contained in the blood upon the central nervous system and upon the endocrine glands.

4. The suppression of acidosis which the oxygen ensures. A shocked individual whose blood-pressure registered 90 or lower was invariably treated on this plan. The records of 300 cases were reviewed, and the results were exceedingly promising.

Uffreduzzi (Turin) gave the results of four series of animal experiments with the object of studying the problem of 'autotoxic' shock. Extracts of pounded or of finely-divided muscle were injected, and investigations were carried out on the blood-pressure, the respiration, the pulse, and the blood

analysis. The author's experience was that the injection of muscle extract in such an amount as to represent the probable degree of absorption from an injured area produced none of the typical changes of shock. Temporary arrest of the venous circulation was without any influence on the development. Injection of muscle previously infected with organisms resulted in death, but no shock evidences accompanied the change. On the other hand, deep shock ensued when the testes were crushed or the sciatic nerves were bruised. From such researches the author concluded that shock is initially of sympathetic nervous origin; it may be that chemical and toxic influences exert a secondary effect, but no evidence was found in support of the primary influence of absorption from an area of bruised or wounded tissue.

Zawadzki (Warsaw) alluded to the shock effects which are manifest during certain manipulations under general anæsthesia. These he ascribed to nerve influences transmitted from the field of operation, and in the correction of them he advised the blocking of the tissue around the field of operation by injection of magnesium sulphate and the administration of morphia and atropine in combination with general anæsthesia.

He recalled the importance of observing the blood-pressure throughout the course of a surgical operation. Adrenalin, caffeine, and injection of serum were advised as suitable for the treatment of the shocked condition when it had become established.

Jirasek (Prague) recorded the results of studies upon shock produced by abdominal operation. Anæsthesia, cold, and infection add their deleterious influence to the effects of traumatism of the viscera. Jirasek made two groups of observations, one with subjects under general anæsthesia, the other under paravertebral anæsthesia, and in both instances he observed a degeneration of the chromaffin cells of the suprarenal capsule. He discussed the probable influence of such a change upon the manifestation of shock, and the conclusion to which he came was that the suprarenal changes exert an influence upon the development of the 'shocked' condition.

SURGICAL AND PARASITOLOGICAL NOTES ON FOUR CASES OF INTESTINAL OBSTRUCTION DUE TO ACCUMULATION OF VERY LARGE NUMBERS OF ROUND WORMS *(Ascaris Lumbricoides).*

By JOSEPH J. LEVIN and ANNIE PORTER, Johannesburg.

The present paper is written in two sections. The first, on the surgical aspects, is by the first-named author, while the second gives brief parasitological notes on the ascarides found, and is by the second author.

I. SURGICAL NOTES (J. J. Levin).

During the period between May, 1920, and May, 1923, there have occurred at the General Hospital, Johannesburg, four cases of acute intestinal obstruction due to large—one might almost say enormous—numbers of round worms (*Ascaris lumbricoides*), and although cases of intestinal obstruction due to round worms have been recorded, yet in the limited literature at my disposal I have not been able to find records of such 'massed' obstruction (nor had one thought it consistent with life) as is revealed in these four cases. With two of them I was associated personally (*Cases* 1 and 3); on *Case* 3 I operated myself. Dr. Dauth operated on two of the cases and Dr. Brebner on one, and I am indebted to these gentlemen for their permission to use their notes and publish their cases.

Case 1.—A Hottentot boy, 11 years of age, inmate of a reformatory, who came under my care as medical officer in that reformatory. The history was that the boy had been convicted in the Eastern Province for theft, and had been sentenced to five years' detention in a reformatory in the Eastern Province of the Cape Colony. When admitted to the reformatory he was apparently in normal health, but later on he was reported sick, and was found to be suffering from phthisis. The medical officer there thought the boy might thrive better at the higher altitude of Johannesburg, and he was transferred to the Diepkloof reformatory, near Johannesburg. He was kept under observation in the reformatory hospital for nearly two months, and was so well that he was put on to light labour, consisting of picking up grass and papers. After he had been discharged from the hospital for a couple of weeks, I was sent for hurriedly to see him on the afternoon of May 4, 1920, and I obtained the history that his bowels had not moved for three days, and that he had vomited a couple of round worms and had also passed a couple per anum. The boy looked extremely ill, and his abdomen was distended and as tight as a drum. His temperature was subnormal, his pulse 136. I made the diagnosis of acute obstruction either by a *ball* of worms or by tuberculous glands, and brought the boy to the General Hospital, Johannesburg,

having previously arranged that he should be taken straight to the operating table. Prisoners, as a rule, come under the care of the superintendent of the hospital, and in his absence the case was dealt with by Dr. Dauth, the senior Resident Medical Officer.

With a middle-line incision Dr. Dauth opened the abdomen, and immediately there presented to him three or four feet of small intestine (jejunum) dilated to about three times the normal thickness and tightly packed with what proved to be round worms. The intestine was incised longitudinally in two places for a length of about 2½ in., and 851 round worms were evacuated from the bowel. Subsequently 48 more worms were recovered from the boy per os and per anum (*Fig.* 262). He was treated with santonin. The intestine was sutured and the abdomen closed without a drain. The worms were taken to Dr. Annie Porter, Parasitologist to the South African Institute for Medical Research, and her report is given on page 437. The boy made an uninterrupted recovery, and was discharged from hospital on June 21. I subsequently obtained his pardon, and he was liberated from the reformatory, since when I have not been able to obtain any further history.

Case 2.—A European girl, age 9 years, an inmate of an orphanage, was admitted to the General Hospital on May 29, 1920, with a provisional diagnosis of acute appendicitis, and with a history that at 9 a.m. on May 28, while running about and playing, she complained of pain in the abdomen. She continued to walk about as usual all that day, and at night vomited three times. On the morning of May 29 a doctor was called in, who sent her into hospital. In hospital the history was elicited that her bowels had not moved for two days. The abdomen was swollen and hard, and it was quite impossible to obtain any information from the examination, as her abdomen was very tender all over. There was marked hyperæsthesia. There was no noticeable lump anywhere. Her tongue was dry and furred, her temperature 97·4°, and her pulse 160. A diagnosis of perforated appendix with general peritonitis was made. Dr. Brebner opened the abdomen and found the large bowel acutely congested in patches. He removed the appendix, in which there were two round worms. He found the jejunum completely obstructed by round worms for a distance of several feet from the duodenojejunal flexure. He opened this portion of the jejunum longitudinally in two places about a foot apart, and evacuated 'several hundred' worms. The intestine was sutured and the abdomen closed. After the operation the patient was collapsed, and did not retain the rectal salines which were administered. The next day she passed five worms per rectum and two per os. She died in the afternoon, never having responded to the treatment for shock.

Case 3.—A European girl, age 8 years, an inmate of the same orphanage as the previous case, was admitted to the General Hospital on April 14, 1923, with a diagnosis of acute appendicitis (?), and a history of having been ill for four days. Her tongue was furred, her temperature 98°, and her pulse 120. The house surgeon on duty sent for me to see her with a view to immediate operation. I did not think that she had acute appendicitis, and decided to keep her under observation. The next day I found that her abdomen was distended and that at intervals she complained of griping pain. The sister of the ward informed me that she got practically no result from the

enemata. Her temperature was subnormal. On the next day, April 16, she looked very pinched and anæmic. On examination her abdomen was distended; at one time it felt doughy and at other times hard and rigid. Her temperature was 99°, pulse 90, and I was informed that she had vomited a round worm and passed one per anum. In the left hypochondrium I thought I could feel a mass. I then made the diagnosis of obstruction with round worms and operated at once. The abdomen was opened with a median abdominal incision below the umbilicus. The ileum was inflamed and collapsed. In the left upper part of the abdomen I felt a mass, and on pulling it out,

FIG. 262.—*Case* 1. 899 *Ascaris lumbricoides.*

FIG. 263.—*Case* 4. Resected portion of jejunum containing 268 *Ascaris lumbricoides.*

FIG. 264.—*Case* 3. Upper jar, 697 female *Ascaris lumbricoides.* Lower jar, 293 male *Ascaris lumbricoides.*

found it to be the jejunum packed tightly with round worms for about 18 in. This part of the intestine was very much distended. I made a longitudinal incision in the intestine over the worms, and, with the assistance of the house surgeon, proceeded with the unpleasant performance of milking out the worms, the majority of which were alive. I found it impossible to milk them all out through the one incision, and made another about the same length—3 in.—a little lower down, and milked out as many as I could through this incision. In all I secured 737 worms. As the child was beginning to show evidence of collapse I sutured the two incisions in the bowel with a double row of catgut sutures, left a rubber drainage tube in the peritoneal cavity,

and closed the abdomen. As I felt sure that all the worms had not been secured, I subsequently treated the child with santonin, and recovered 253 more by this means. I took the worms found at the operation to Dr. Annie Porter, and also had those that were recovered afterwards sent to her. The total number of worms obtained from this child was 990 (*Fig.* 264). Dr. Annie Porter's report follows. Although the child did not develop general peritonitis, which I dreaded she might, there was a little superficial sepsis in the wound where the tube had been. She, however, made an uneventful recovery and was discharged from the hospital on May 22, 1923. She went to the Hospital Convalescent Home, and after a month had put on weight, developed rosy cheeks, and looked a very happy, healthy child.

Case 4.—A European girl, age 10 years, was admitted to the General Hospital on May 21, 1923, from the same orphanage as *Cases* 2 and 3, with a diagnosis of acute appendicitis. Her temperature was 100·8°, her pulse 138, and she looked intensely ill. The abdomen was distended, and in the epigastrium Dr. Dauth thought he could feel a mass, which was dull on percussion. The child complained of acute pain in the abdomen, and the history was obtained that she had been ill for four days and that her bowels had not moved during that time. The abdomen was opened by Dr. Dauth through a right rectus incision, and immediately gas escaped through the aperture. He found a milky fluid free in the peritoneal cavity. The incision was extended in an upward direction, and a portion of the jejunum was found to be gangrenous and perforated in three or four places (presumably by the worms). About two feet of bowel, including the gangrenous portion, was resected. This portion was tightly packed with round worms (*Fig.* 263, —some of the worms have dropped out of the bowel and are seen at the bottom of the jar). In addition, "hundreds" of round worms were evacuated from a portion of the jejunum lower down, adjacent to the gangrenous portion, through a longitudinal incision in the bowel. Subsequently 268 worms were removed from the resected portion of the bowel. All the worms which had been evacuated from the portion of the jejunum lower down were put into a bucket and unfortunately thrown away, and therefore could not be counted. Dr. Dauth, however, stated that there were "hundreds" of worms. The abdomen was closed without drainage, and the child died the same night.

For the sake of convenience the salient points of the cases are tabulated. It will be noticed in the histories that there are certain points of similarity in the four cases: (1) All came from institutions and not from private homes; (2) All gave a very short history, although they had presumably been infected for quite a long time; (3) All were about the same age; (4) The majority (three) were females; (5) The majority (three) came into hospital with the diagnosis of acute appendicitis; (6) In all, the jejunum was the portion of the gut in which the worms were impacted.

As stated above, the literature at my disposal is very meagre, but I find recorded in the *Journal of the American Medical Association*, 1923, Jan. 20, a case of intestinal obstruction due to nine round worms, in which a resection had to be done by Dr. Baugh, of Albany; also in the *Journal of Tropical Medicine and Hygiene*, 1922, July 1, a case is recorded by Dr. Ingram which is of great medico-legal and surgical interest. In this case he found twelve

round worms in the bowel, and a perforation of the bowel, probably caused by a worm pushing its way through a weakened part of the wall of the gut. In the résumé of current literature in the *Journal of the American Medical Association*, 1921, Feb. 12, reference is made to two cases by Gilberti : in both the bowel had been perforated by round worms. In the one case two worms were found, and in the other three. The one was successfully operated on and the other case ended fatally. In the 1921, 1922, and 1923 *Quarterly Cumulative Index to Current Medical Literature*, published by the American Medical Association, there are a few other references to cases of obstruction with round worms, but as the journals quoted are not available, I cannot give the details of the cases.

TABLE SHOWING DETAILS OF THE CASES.

	CASE 1	CASE 2	CASE 3	CASE 4
Age and sex ..	11, Male	9, Female	8, Female	10, Female
Race	Hottentot	European	European	European
Residence ..	Reformatory	Orphanage	Orphanage	Orphanage
Time ill	3 days	2 days	4 days	4 days
Provisional diagnosis	Intestinal obstruction	Acute appendicitis	Acute appendicitis	Acute appendicitis
Condition found at operation ..	Intestinal obstruction	Intestinal obstruction	Intestinal obstruction	Intestinal obstruction and perforation. Gangrene of bowel
Portion of intestine involved	Jejunum	Jejunum	Jejunum	Jejunum
Number of worms recovered at operation	851	"Several hundreds"	737	268+"hundreds" thrown away
Number of worms recovered subsequently	48	7	253	None
Proportion of male to female worms ..	1 : 6	Unknown	3 : 7	5 : 12
Average length of worms	Males 5 in., females $6\frac{3}{4}$ in.	Unknown	$3\frac{1}{2}$ in.	$5\frac{2}{5}$ in.
Result of operation ..	Cure	Death	Cure	Death

II. PARASITOLOGICAL NOTES (A. PORTER).

Ascaris lumbricoides, the large round-worm of man, is a common parasite both of Europeans and of natives in South Africa. The infestation is often relatively slight, but on occasions I have obtained fifty to sixty worms at post-mortem examinations of human intestines. Larger numbers have been rare. It is known that among round-worms there is often predominance of one sex over the other, and Brumpt (1921) has shown experimentally that, in the case of *Strongyloides papillosus* in sheep, 2000 females develop to 1 male worm. If the infection is produced in rabbits, the proportion alters greatly, the ratio of females to males being 409 to 237. Whether the proportion of

female to male ascarides varies in Europeans and natives remains as yet uncertain, and more cases need investigation. There are, however, indications that such differences may occur.

The cases of massive infestation with ascarides that are discussed here came under the notice of my co-author, Dr. Joseph J. Levin. In two of them all worms removed at operation and also those passed subsequently came into my possession. In one case a length of gangrenous intestine, greatly distended by densely packed ascarides, was available, but the greater part were destroyed in hospital. Of the remaining case, I regret that no material came to me.

The parasitology of the three cases may now be given :—

Case 1.—The worms received immediately after the operation on the young Hottentot boy numbered 851. Subsequently, 48 more worms were received, having been recovered from the boy per os and per anum. There may have been even more worms, for fragments were received on several occasions that were incapable of reconstruction into complete worms, some having been semi-masticated. Of the 899 worms (*Fig.* 262, *Case* 1), the larger number were females, and the proportion was approximately 1 male to 6 females, the actual numbers being 128 males and 771 females. The worms were relatively long, the average length of the females being $6\frac{3}{4}$ in. and of the males 5 in.

Case 2.—In this instance unfortunately the worms evacuated at operation were not preserved.

Case 3 was an even more massive infestation than that of the Hottentot boy. The little European girl was aged 8. Immediately after the operation the mass of worms was brought to me by Dr. Levin. I sorted and counted them. There were 737 in all, made up of 222 male and 515 female *Ascaris lumbricoides*. All worms passed by the child after operation were put into formalin and sent to me. Eleven days after the operation I received a set of worms consisting of 16 male and 78 female ascarides. Treatment with a vermifuge was commenced, and five days later a consignment found to consist of 55 male and 101 female ascarides was received. This was the last large number of worms, but after an interval of twenty-one days 3 macerated female ascarides reached my laboratory. Since then no more worms have been passed, though the child has been under observation for more than a month. The total number of worms received was 990 (*Fig.* 264, *Case* 3). The proportion of the sexes is roughly 3 males to 7 females, the actual numbers being 293 males and 697 females. The average length of the worms was $3\frac{1}{2}$ in.

Case 4.—The patient was a European girl, age 10. Most unfortunately only the portion of gangrenous intestine removed at operation and a very few of the worms were available, some 'hundreds' removed at operation having been destroyed. The portion of jejunum with some of the worms that had dropped out was photographed (*Fig.* 263, *Case* 4). It was then opened and 268 ascarides were removed. Of these 188 were females and 80 males. The proportion of male to female worms was thus roughly 5 to 12. Had all the worms removed at operation been available, the proportion of the sexes would probably have been different, judging from the variations found in the successive batches of worms obtained from *Case* 3. The size of the worms was also larger than those in *Case* 3, the average length being $5\frac{2}{5}$ in.

From the three cases examined it is evident that there is a marked difference in the numbers of male and female ascarides found. Examination of my post-mortem records shows that similar differences in the numbers of male and female worms are usual, though in none of these records have such large numbers of worms been noted, nor were any of them cases of intestinal obstruction.

There is also a difference between the proportion of male to female ascarides as found in a native and a European case. Whether such may be due to differences between the native and European intestine cannot be stated until many more cases have been examined, but the conditions observed seem to suggest that the milieu of the native intestine is less favourable to the male ascaris than that of the European intestine, the converse being the case for the female worm.

There is some interest attaching to the fact that all three European children were inmates of the same orphanage. Two of these three cases occurred within a month of each other. The ease and speed with which round-worm infestations spread among inmates of institutions is no new thing.

In connection with infestation by *Ascaris lumbricoides*, it may be of service to summarize the life-history of the worm, so ably worked out by Major F. H. Stewart, I.M.S., published during the period 1916–18, and since confirmed by a number of workers. Until recently it was believed that an invertebrate host was necessary for *Ascaris*. Such is not the case, infection occurring by direct ingestion of ova. Ripe ova have been found to give better results in experimental animals than freshly shed ones. Stewart found that the larvæ hatch from the ova in the small intestine, but do not remain there, as at first they cannot resist the action of the digestive juices. The larvæ are fragile, but they bore through the mucosa, and reach the liver by way of the blood-stream. From the liver they migrate to the lungs, where they remain about eight days. They then begin to pass into the trachea, and on about the ninth day some begin to migrate back to the intestine, though others persist in the lungs for as long as fifteen days. By the tenth day migration via the œsophagus or the mouth towards the intestine is well established, and the larvæ pass rapidly through the stomach into the small intestine of the host. The passage of the larvæ through the lungs is attended by bronchitic symptoms, and 'verminous bronchitis' is due to *Ascaris* as well as to other causes. Stewart states that there is "reason for supposing that a great deal of the debility of the natives of the tropics is due to ascariasis, and that this disease is at least equal to ankylostomiasis in economic importance". Its rôle in intestinal obstruction is well shown in the present series of cases.

In Johannesburg I have been able to confirm Stewart's work in all essential points. There are slight differences in the times necessary for development of ova and larvæ, but this is considered to be due to climatic differences, Johannesburg being far inland and at an altitude of nearly 6,000 feet, while Stewart's experiments were carried out in Hong-Kong, at sea level.

ASEPTIC INTESTINAL ANASTOMOSIS: WITH SPECIAL REFERENCE TO COLECTOMY.

By JOHN FRASER and NORMAN M. DOTT, Edinburgh.

It is a somewhat suggestive fact that it is difficult to obtain any large amount of statistical evidence regarding the results of, and the mortality associated with, the operation of colectomy. The explanation probably is that the majority of us are disappointed with the results we obtain, and it is but natural that indifferent results are rarely published. Under any circumstances the operation of enterectomy is a grave one; removal of a portion of the large intestine is a more serious procedure than a corresponding operation on the small intestine, and it is instructive to notice that colectomy of the distal portion of the large intestine is a more dangerous operation than a corresponding removal of the proximal segment.

The Evolution of the Operation.—Evidence of the difficulties which surround the operation is suggested by the variety of methods which have been put forward from time to time; they may, in fact, be divided into epochs in the evolution of the operative treatment. With the advent of what we may term 'modern surgery', enterectomy was attempted by axial anastomosis with sutures; but the results were so disappointing that an attempt was made to improve them by the use of various mechanical contrivances, the best known of which is probably Murphy's button. The disadvantages of such appliances soon became obvious, and there was a return to suture anastomosis—lateral anastomosis, however, being substituted for the axial union. The results were improved by this departure, and, as far as colectomy was concerned, union by lateral anastomosis remained the procedure of choice until within the last ten or fifteen years. During this period there has been a return to the axial union by suture, but the safety of the suture line has been more fully guaranteed by the previous institution of a cæcostomy or a colostomy.

The want of stability implied by such a variety of methods would seem to indicate dissatisfaction with results, and therefore it is interesting to recall a summary of the operative statistics which are available.

Statistics.—The paper which Paul,[1] of Liverpool, published in 1895 may be said to have been a landmark in the progress of colectomy. He was the first to advocate the two-stage operation, and he published records of 14 cases with only a single fatality, and that was an instance in which the rule was broken and the complete operation carried through in one stage. Paul in his paper emphasized the danger of the one-stage operation, and in 1903 Mikulicz[2] issued an interesting report bringing out the contrast between the results of the one-stage and the two-stage operation. The first showed a mortality of 42·9 per cent, the second a mortality of 12·5 per cent. In this

country Pollard,[3] Littlewood,[4] and Mayo Robson[5] in the years 1903 and 1904 recorded various groups of colectomies, all of which were performed by the two-stage method, and, except in Pollard's series, where there were 7 cases without a death, the average mortality was from 7 to 10 per cent.

These various figures are too small, however, to afford any trustworthy statistical information, because specially favourable conditions might coincidently establish good results. In 1907 Hartmann[6] collected 143 cases of enterectomy (colectomy) for malignant disease, with a mortality of 33·5 per cent, and in the same year Anschutz,[7] working in Mikulicz's clinic, collected 139 one-stage operations from the literature with a mortality of 46 per cent, and as a contrast he collected a number of the two-stage operations with a mortality of 18 per cent. Finkelstein's figures, as quoted by Oppel,[8] are 29 and 16 per cent respectively; Mayo,[9] using the two-stage method, recorded 184 cases, with a mortality of 17 per cent. A number of other collections of statistics exist, but most of them correspond to the figures quoted above, and the position may be summarized by saying that the operation of colectomy as a single-stage operation is associated with a mortality of about 30 per cent, and in the two-stage operation with a mortality of about 10 per cent. The results of the temporary cæcostomy method are about the same as those of the two-stage operation.

These figures indicate an unsatisfactory position. The statistics represent the results of picked cases—cases, in other words, which have been suitable for operation—and therefore the best of the mortality figures is uncomfortably high.

The Difficulties and Dangers of the Operation.—It is not difficult to see the explanation of the dangers which surround the operation. Peculiarities of blood-supply, and the highly septic contents of the large intestine, coupled with their solid nature, are the factors which render surgery of the colon so dangerous. The blood-supply and sepsis are closely interrelated, and the influence of either must be very strongly reflected on the other. Of all the various factors, however, sepsis is the most serious. When we consider the highly infective content of the large intestine and the soiling which must inevitably occur in the ordinary 'open' methods of colectomy, it is wonderful that the results are as good as they are. It is no exaggeration to say that when the ordinary open operation is performed, the individual operated on must overcome a local peritonitis before his recovery is assured. In fact, the element which gives the operation its serious character and its associated high mortality is essentially one of infection, and the abolition of this factor may well revolutionize the operation results. The existence of organisms within the bowel is a physiological condition which cannot be prevented; in the presence of obstructive lesions the intensity of the intestinal flora is accentuated, and there is probably an associated increase in the incidence of such actively pathogenic organisms as the streptococci.

But, coupled with the existent potential sepsis, there are questions of blood-supply and of structural peculiarity which increase the dangers. The former may be said to be arranged on a somewhat sparse plan: the arteries supplying the colon pass round the bowel in a circular direction from the mesenteric border and are parallel to each other. There is very little

anastomosis between the different vessels in the wall of the colon, and though there is a comparatively free inosculation at the mesenteric attachment, the free edges of the bowel are by contrast very scantily supplied with blood. A profuse and active blood-supply is one of the best safeguards against the development of sepsis, and therefore the comparative sparsity of the colon supply is a factor which must be taken into consideration—the combination of sepsis with the small blood-supply must exert an unfortunate effect upon the healing process after colectomy.

A second factor of great practical importance is the presence of subperitoneal deposits of fat on the colon wall. In stout subjects the fat may so completely envelop the colon that it will be difficult to find any extent of uncovered serous surface, and its presence may give rise to serious difficulties in accurate approximation and efficient suturing. Hence the further risk that in the presence of even a minor degree of sepsis the fat quickly necroses and sloughs.

Lastly, it is important to remember that in certain situations the relationship of the peritoneum to the colon wall is such that portions of the bowel are uncovered with peritoneum and so come into contact with the retroperitoneal connective tissue. There is thus a space of high absorption possibilities; it is profusely supplied with lymphatics, and infection, once introduced into the area, may make rapid progress to a fatal termination. In such dangerous situations the mortality of colectomy is increased by the occurrence of the highly fatal retrocolic cellulitis. In fact, as we have already said, it is the occurrence of sepsis which makes this operation of colectomy such a fatal one, and if this danger is overcome the procedure will lose much of its present risk.

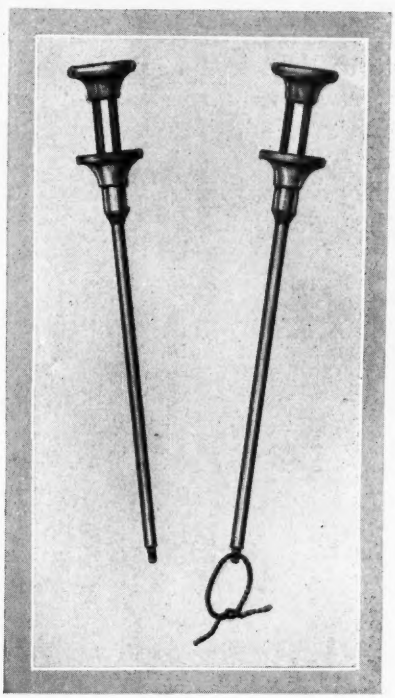


FIG. 265.—*Ligature guillotines.* The instruments measure 6 cm. in length, and the tubular sheath is 2 mm. in thickness. Projecting from its end is seen the solid, centre wire, with an eye in its extremity. The flanges, which constitute the handle of the instrument, are arranged like the antinous release of a camera, so that the central wire can be drawn into the sheath. One instrument is represented with a ligature threaded in place. It will be seen that, when the flanges are pressed together, the ligature is cut against the end of the tubular sheath; moreover, the guillotine cannot be released from the ligature until the latter is completely severed.

This paper is actually an account of an attempt which we have made to overcome the dangers and to minimize the difficulties of enterectomy in general and of colectomy in particular. It is obvious that an efficient sterilization of the interior of the bowel is impossible, and therefore the only way in which to avoid infection is to prevent any direct opening of the bowel lumen while the operation is in progress. We believe we have achieved this ideal in the method we describe.

DESCRIPTION OF THE METHOD AS USED IN AXIAL ANASTOMOSIS.

We at first contemplated attempting aseptic anastomosis by securing the stumps of gut in the grasp of snares, inserting a circular suture, cutting through and releasing the stumps by means of the snares, and withdrawing the latter through the suture line; but the technical difficulties appeared considerable, the asepsis to be anticipated doubtful, and we noted that Burket had tried a similar method and found it imperfect. It then occurred to us that, if the stumps were closed by means of ligatures, and the ligatures were severed by means of snares after anastomosis of the stumps, the difficulties would be overcome. In this way very fine snares or guillotines may be employed, and, as they touch only the peritoneal surface of the bowel, they carry with them no risk of contamination as they are withdrawn through the suture line. After successful experimental trials, carried out in the

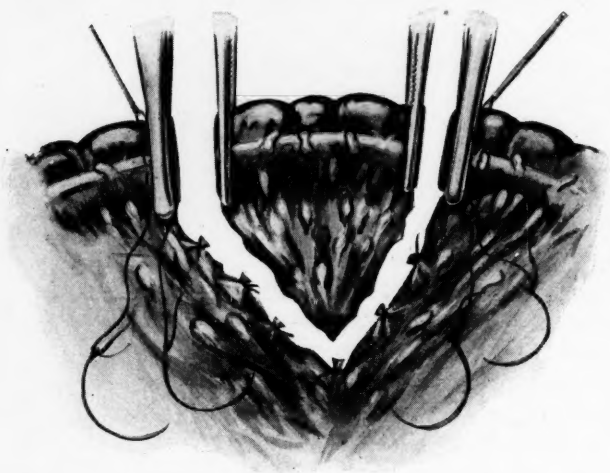


FIG. 266.—*Resection.* The segment of gut to be excised has been isolated with a wedge-shaped portion of mesentery attached. The gut has been divided between the pressure forceps and crushing clamps and is about to be removed. The insertion of the purse-string sutures for closing the stumps is shown, and the position of the ligature guillotines upon them is indicated.

Department of Physiology, Edinburgh University, by kind permission of Professor Sir E. Sharpey Schafer, we have applied the method to clinical cases of carcinomatous obstruction of the colon. The gratifying results obtained appear to us to warrant a detailed report of the method.

Resection and Reconstruction.—The only special instruments required are the two ligature guillotines (*Fig.* 265); the usual crushing clamps* are employed, but controlling clamps are dispensed with.

1. *Resection* (*Fig.* 266).—The resection is carried out in the usual manner. The mesentery and lymphatic fields are mobilized as may be necessary, the segment of bowel to be removed is secured at each end by pressure forceps; the mesentery is perforated at these points, and it is secured and cut so that

* Payr's model is very convenient for the purpose.

a wedge-shaped portion is removed. Strong crushing clamps are applied to the gut close to the two pressure forceps, and the gut is divided between them at each end. The segment of bowel enclosed between the pressure forceps, with its attached mesentery and lymphatic field, is removed immediately *en bloc*. The division may be made either by the electric cautery or by the knife; in the latter case the section is carried flush with the clamp, and the cut edge touched with liquid carbolic acid. The vessels of the resected mesentery may now be tied off.

2. *Preparation of the 'Blind Ends'* (*Fig.* 267).—The ends of the gut are now to be ligatured, and it is safer to employ a purse-string suture for the purpose in order to obviate the risk of its slipping. The ligature guillotine is threaded upon, and placed about the middle of, a strand of strong catgut, and each end of the latter is armed with a needle. The suture is inserted close to the edge of the crushing clamp. Commencing with one needle at

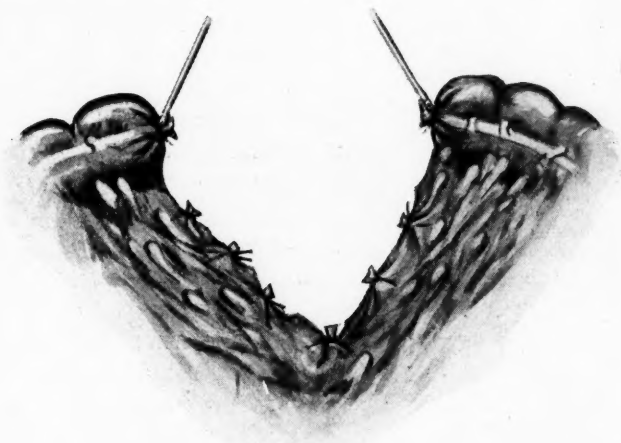


FIG. 267.—*Preparation of blind, aseptic ends.* The crushing clamps have been removed and the ligatures tightened and tied off. Note the small stumps of crushed tissue which project from the centre of the blind ends of the bowel, and the position of the ligature guillotines upon the controlling ligatures.

the antimesenteric border of the bowel, a few points of seromuscular suture are taken up to terminate at the mesenteric attachment. With the other needle the procedure is repeated on the other half of the circumference. Thus, when the ligature is tightened, the guillotine remains attached to the antimesenteric border, while the knot is at the mesenteric attachment. As the clamp is released the ligature is drawn tight and tied as above. The end of the bowel is converted into a 'blind end', with a minute stump of thoroughly crushed tissue projecting at its centre (*Fig.* 267). Although the crushed tissue contains no mucous membrane, we have taken the precaution of making a further application of the cautery or of liquid carbolic acid to it to ensure asepticity. The ease with which the stump can be invaginated into the end of the bowel should be tested, that there may be no tension on the anastomosing sutures. If necessary the mesentery should be further divided, to permit of easy inversion. It will be noted that the ends of the bowel have

been prepared for anastomosis without at any time exposing the mucous membrane. They are aseptic and securely closed, so that they can be freely handled without apprehension of contamination.

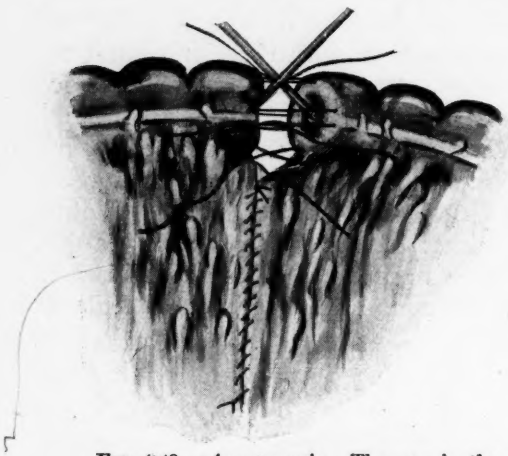


FIG. 268.—*Anastomosis.* The gap in the mesentery has been closed. The interrupted mattress sutures have been inserted, but not tied. (In practice, each is tied as it is inserted.) Note particularly the crossed mattress suture controlling the area of mesenteric attachment, and the slight inversion of the stumps which permits approximation of the circumference when the stitches are tied.

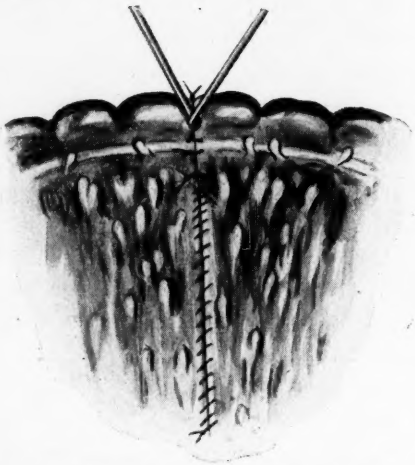


FIG. 269.—*Anastomosis.* The mattress stitches have been tied and the ends of the bowel thereby approximated. This constitutes the first line of suturing. The ligature guillotines are seen projecting through the suture line at the antimesenteric border.

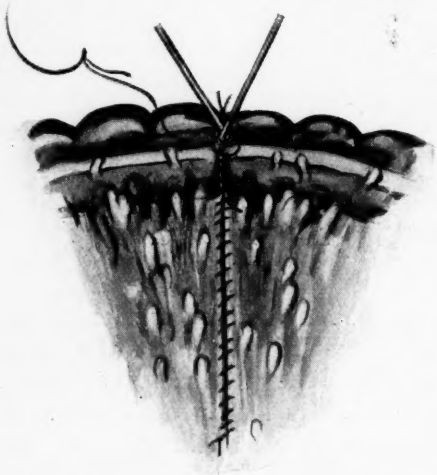


FIG. 270.—*Anastomosis.* The continuous circular suture has been inserted. Commencing at the antimesenteric border on the distant side of the guillotines, it has passed round, traversed the mesentery, and terminated in a loose stitch over the point of emergence of the guillotines.

3. *Reconstruction of Continuity.*—It is convenient to close the gap in the mesentery in the first place, and the guillotines attached to the ends of the bowel, employed as tractors, greatly facilitate this procedure. The mesenteric borders of the ends of the bowel are approximated by a mattress suture, and three or four interrupted stitches uniting the remainder of their circumferences form the first line of union (*Figs.* 268, 269). The stitches of tanned catgut should penetrate to the submucous coat. As they are tightened, the stumps are allowed to invert slightly into the ends of the bowel. The ends form a double diaphragm across the lumen. The thin guillotines are allowed to project together through the suture-line at the antimesenteric border. If the field of operation is difficult of access, it is well to pay special attention to the area of mesenteric attachment, inserting two or more superimposed mattress stitches before the remainder of the circumference is united.

By this precaution easy access to this 'danger point' and its secure closure are ensured in the most difficult case. A circular Lembert suture of fine tanned catgut is carried round the circumference of the anastomosis. Commencing at one side of the guillotines on the antimesenteric border, it passes round to the mesenteric attachment; the needle is passed through the mesentery eye-first, and the suture continued to reach the antimesenteric border again. It is completed by taking a loose stitch over the guillotines (*Fig.* 270). The original ligatures on the stumps are now cut by means of the guillotines, and the latter are withdrawn. The loose stitch is tightened and tied off, so closing the point of exit of the instruments (*Fig.* 271). In this way the stumps are released and intestinal continuity is re-established (*Fig.* 272). In dealing with the human colon we have thought it wise to superimpose a second continuous circular suture of linen thread. (We now have reason to believe that tanned catgut is preferable: *see below.*) We may mention, however, that the approximating and single circular catgut sutures were relied on in experimental work and found entirely satisfactory. The adequate zone of complete peritoneal apposition between the two lines of stitches (*Fig.* 272) should be particularly noted.

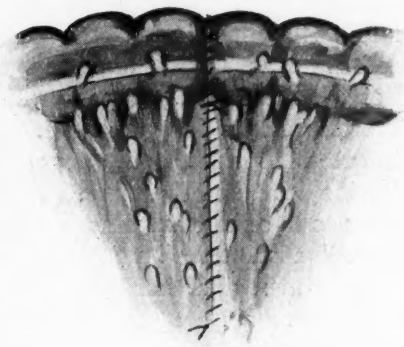


FIG. 271.—*Anastomosis.* The internal controlling ligatures have been cut by the guillotines and the latter withdrawn. The loose stitch has been tightened and tied off, so closing their point of exit. Anastomosis is complete—intestinal continuity is re-established. A further circular suture may be inserted (*see* text).

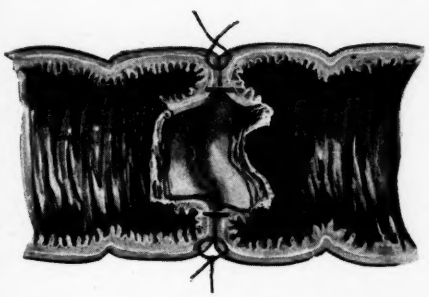


Fig. 272.—*Sectional view of completed anastomosis.* The diagram shows the area of complete apposition between the inner row of interrupted sutures and the outer circular row. This area can be increased as desired by insertion of an additional line of circular sutures. The inturned cuffs of bowel with crushed edges are shown. It will be readily appreciated that, the whole structure being soft and mobile, the cuffs of bowel are opened out in the direction of intestinal flow, so as to give an ample lumen. Experience has shown that these cuffs entirely disappear.

In this way the resection and anastomosis can be carried out rapidly and aseptically, and they can be performed in situations which would preclude the use of controlling clamps, and in which the ordinary methods of suture would be extremely difficult or impossible. Although their description is necessarily somewhat intricate, the resection and reconstruction can be completed easily within fifteen minutes in a straightforward case.

TECHNIQUE OF END-TO-SIDE ANASTOMOSIS BY ASEPTIC METHOD.—End-to-side ileocolostomy may be selected for descriptive purposes. The ileum is divided between a pressure forceps and crushing clamp, the crushing instrument being applied to the upper segment. The lower segment is closed by

purse-string suture and invaginated as usual. The upper segment is prepared as a blind aseptic end with ligature guillotine attached, as described for axial anastomosis. From the antimesenteric aspect of the wall of the colon a little cone is drawn out with forceps, the crushing clamp is applied to the base of the cone, and the apex is cut off with knife or cautery. A sufficient amount should be clamped and removed to obviate the risk of missing a loose and folded mucous membrane. Inspection of the cap of tissue removed will reflect the size of the opening which has been made, by the island of mucous membrane on its inner surface. The cut edge in the grasp of the clamp is disinfected as described above, and the purse-string suture with ligature guillotine threaded is inserted close to the clamp. The subsequent steps are exactly as in axial anastomosis; in short, after picking up the cone and cutting off and ligaturing its apex, the stump is treated as if it were an 'end stump'.

The operation has proved very satisfactory experimentally. As the internal ligatures are severed in the last stage of the procedure, one observes the junction expanding as the lateral opening in the colon springs open. We have not yet had occasion to apply this method in human surgery.

EXPERIMENTAL STUDY.

It was, of course, essential to conduct a thorough experimental test of our method of intestinal anastomosis before applying it to the human subject, and a brief account of the experiments and their results may be of interest. The experimental animal selected was the dog, as it is the available animal whose intestinal tract most closely resembles that of man. The chief points

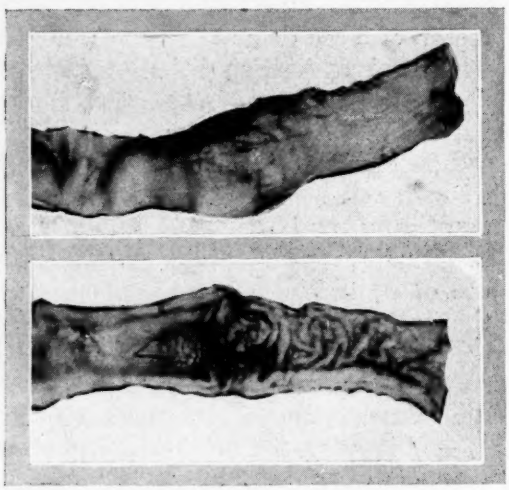
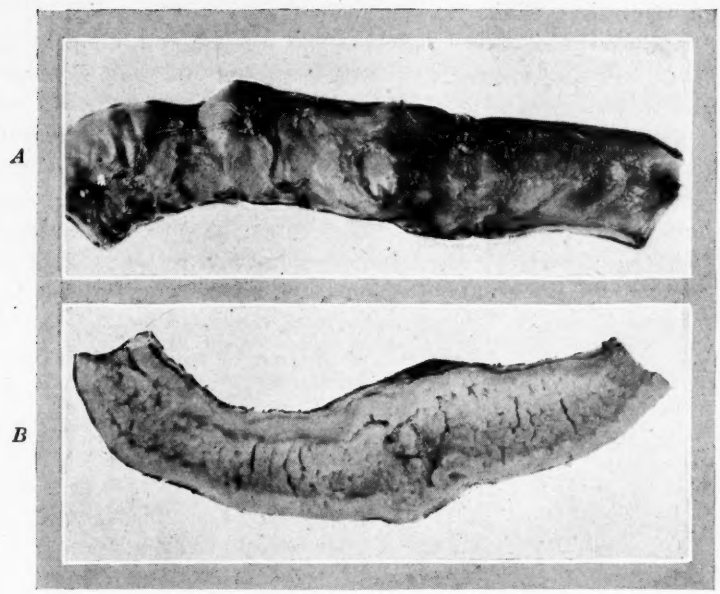


FIG. 273.—Dog 8/23. Specimen of axial anastomosis of transverse to pelvic colon, removed 36 hours after operation (fixed in formol).

A, External appearances. Note the smooth, completely healed suture line. The slight expansion of the bowel at the junction is due to greater fixation shrinkage of the gut above and below it.

B, Internal appearances. Note the inturned cuffs whose crushed edges have already sloughed off. There is an adequate lumen, and the soft, projecting cuffs are easily folded aside by intestinal contents.

which required investigation were: the possibility that the inturned cuffs might cause intestinal obstruction; the possibility of uncontrollable hæmorrhage from the free edges of the cuffs; the possibilities of late complications, such as stenosis or polypoid formations, should the inturned cuffs persist as projections into the lumen of the bowel; the comparative merits of our method as compared with others as regards facility and rapidity of conduct.



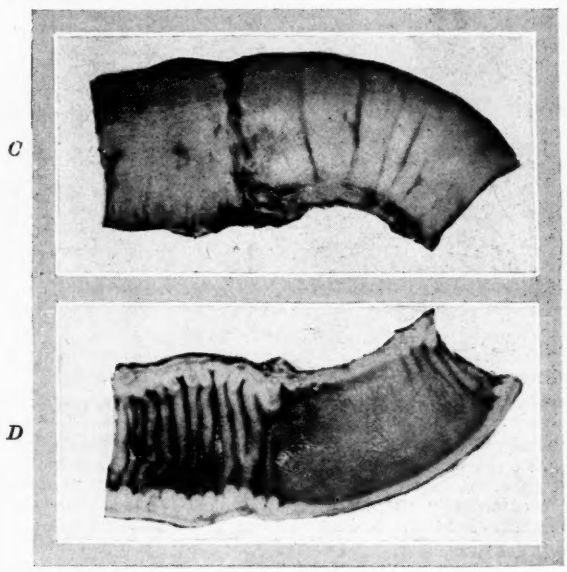


Fig. 274.—Dog 6/23. Specimens of axial anastomosis of small and of large intestine, after double resection, removed 73 days after operation (fixed in formol).

A, Small intestine—jejunum : *external appearances.* The suture line is barely recognizable.

B, Small intestine : *internal appearances.* No evidence of the site of junction remains on the mucosal surface.

C, Large intestine—transverse colon to rectum : *external appearances.* The outline of the bowel is quite smooth. The line of anastomosis is recognizable as a shallow, circular depression.

D, Large intestine : *internal appearances.* The line of anastomosis is not visible. The junction of the comparatively smooth-walled transverse colon with the rugose rectum is, however, very obvious.

It should be noted that the conditions of the experimental test were more stringent than those of clinical practice for the following reasons: the intestinal wall of the dog is much thicker than that of man in proportion to the calibre of the lumen, and obstructive complications were therefore more to be feared; the greater relative thickness of the wall of the canine intestine is dependent on its plain muscular tissue, and this tissue, being comparatively inflexible, inturning without undue tension is more difficult of accomplishment; and, owing to the greater preponderance of pure muscular tissue, as contrasted with the fibrous element, sutures have a less secure hold. Thus,

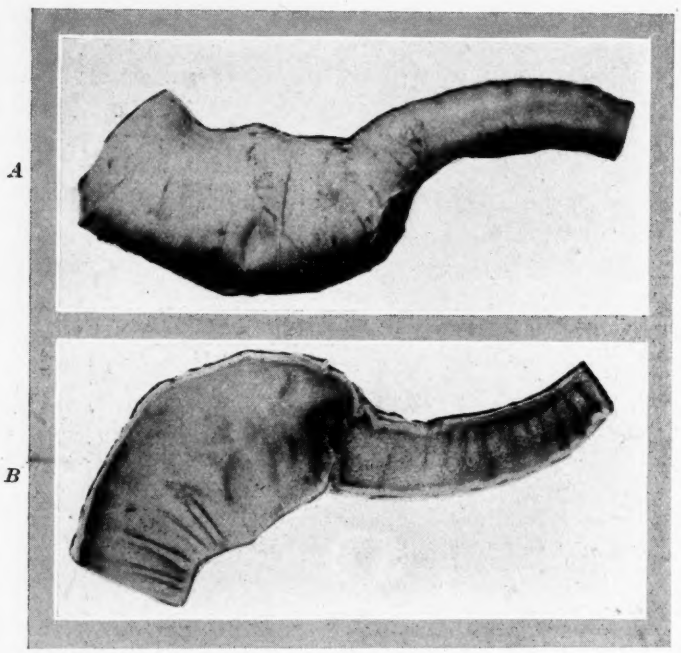


FIG. 275.—Dog 5/23. Specimen of axial anastomosis of ileum to transverse colon following right hemicolectomy, removed 70 days after operation.

A, External appearances. The suture line is unrecognizable, and the ileum passes smoothly into the colon.

B, Internal appearances. In this case the inturn has not entirely disappeared, but projects, valve-like, into the colon. In the fresh specimen we were able to demonstrate that it acted as a very competent ileocolic valve, allowing a perfectly free stream in the normal direction and almost completely obstructing flow in the opposite direction. It is possible that its persistence in this case may have had some relation to this normal valvular function.

having satisfied ourselves regarding the possible difficulties by experiment on the dog, we feel that we can recommend the method with considerable confidence as a reliable and practical surgical procedure. Our experience in its clinical application entirely supports this opinion.

The following operations were performed on dogs, some of which were adult animals and some young puppies: (1) Four segmental colectomies, completed by axial reconstruction. In two of these a segment at the splenic flexure was removed; in two the entire pelvic colon was resected. (2) Two right hemicolectomies, in which continuity of the intestines was re-established

by axial anastomosis of the ileum to the transverse colon. (3) Two short-circuiting operations by end-to-side ileosigmoidostomy. (4) In one case (a puppy of 2½ months), segmental resection of the jejunum and left hemicolectomy were performed at one sitting, both excisions being followed by axial anastomoses. These operations were very well tolerated. Most of the animals took a good fluid meal within two to four hours of the operation, and within twenty-four hours they would play with their companions, showing no evidence of discomfort. Post-operative vomiting occurred in only two instances, and in them it was limited to the first twenty-four hours. Thus temporary obstruction—even in the presence of a double resection—was excluded as a possible danger. A trace of dark blood was always present in

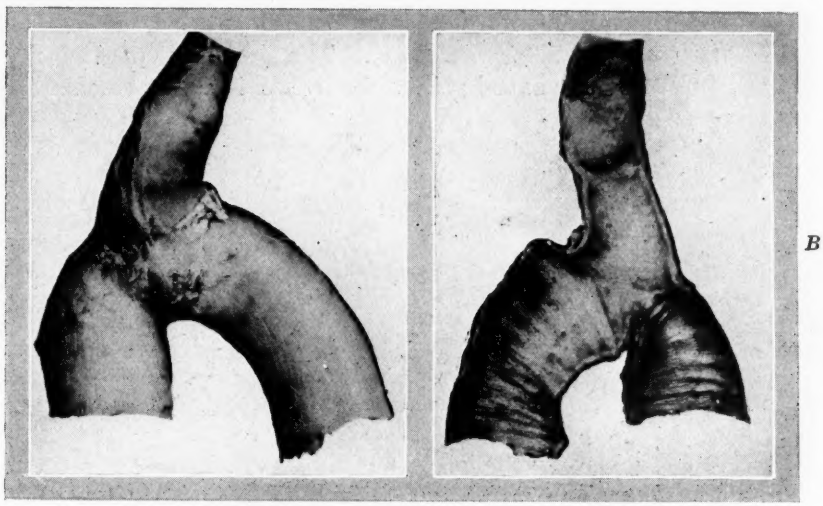


FIG. 276.—Dog 2/23. Specimen of end-to-side ileosigmoidostomy, removed 78 days after operation.

A, External appearances. The suture line is only marked by the conformation of the junction of the intestines. The ileum is seen to enter the convexity of the sigmoid loop at a right angle. The junction is smooth, and shows no constriction or angulation.

B, Internal appearances. The different textures of the ileal and colonic mucous membranes is the only indication of their site of junction. Note the wide, free lumen between the ileum and the lower functional limb of the colonic loop. The constriction at the mouth of the upper limb of the loop is more apparent than real, and is due to fixation in a folded position.

the first motion after operation, which was usually passed on the second or third day; and traces were occasionally noted for three or four days subsequently. The melæna was not greater in amount than that which follows any method of intestinal anastomosis. The motility of the intestine was, of course, temporarily deranged by the operative manipulations, as evidenced by one or two days' constipation. It did not persist beyond this period, after which in all cases the bowels acted quite normally. The examination of specimens of the various types of anastomosis mentioned above demonstrated that within a maximum of seventy days the inturned cuffs of bowel were so completely absorbed as to project no further into the lumen than the normal mucosal folds. Thus late complications in connection with the inturned

cuffs need not be considered as a menace to the success of the operation. The crushed edges slough off into the interior of the bowel within the first twenty-four hours (*Fig.* 273). A temporary ulcer is present for some time during the healing process at the apex of the inturned fold (*Fig.* 277); it is certainly healed by the thirtieth day—probably much earlier, but we have not, as yet, followed out the intermediate stages of healing. Reduction in size of the infolded mass is effected at first by sloughing and to a slight extent by ulceration. Its continued reduction after healing of the ulcer is due to natural atrophy and absorption occurring in a functionless tissue.

Microscopical examination of the line of suture seventy to eighty days after operation reveals the extraordinary powers of adaptation and reconstruction which the tissues of the bowel possess. At this time the place of junction of the mucous membrane cannot be identified, so perfect is its regeneration (*Figs.* 278, 279, 280, 281). The junction of the muscularis mucosæ is slightly less advanced; in some cases it is represented by loose

FIG. 277.—Dog 8/23. Axial anastomosis of the colon, after resection of segment at splenic flexure. Microphotograph (× 7) of suture line 36 hours after operation. The crushed edges have sloughed off. A narrow, temporary ulcer exists at the apex of the inturned mass. The wide area of peritoneal apposition, already firmly sealed by fibrin, is seen.

submucous tissue only (*Figs.* 278, 279, 280); while in others small, newly-formed muscle fibres have bridged the gap (*Fig.* 281). The submucous tissue is somewhat thinner and denser in texture than elsewhere, but it has by no means a compact, scar-like structure. The junction of the muscular coats is in all cases evident from the small, angular depression on their outer surface where they had been folded in. The depression is entirely filled by fibrous tissue of loose texture. In all cases at about seventy days (*Figs.* 278, 279, 280) the junction is clearly demarcated by the direction of the muscle fibres, which turn inwards at this point. Loose connective tissue binds together their former external surfaces, from which the peritoneal covering has disappeared. At about eighty days a commencing rearrangement of the muscle is evident, and many small, newly-formed fibres and bundles are seen permeating the loose connective tissue and re-establishing complete muscular continuity (*Fig.* 281). The peritoneal endothelium passes smoothly over the fibrous tissue which fills the depression between the inturned muscular coats.

The most remarkable feature of the suture line is the absence of anything

approaching to dense, scar-like, fibrous tissue, and the re-establishment of normal anatomy—complete in the mucous membrane, and obviously in progress in the outer coats.

Some points of general interest emerge from the microscopical examination of the specimens. As already mentioned, only 0000 tanned catgut was

FIG. 278.—Dog 6/23. Axial anastomosis after enterectomy. Microphotograph (×7) of suture line 73 days after operation.

The evidence of a mucosal wound has been entirely effaced by reconstructive growth, with the exception of the muscularis mucosæ, which is not yet reconstituted. The muscular tissue of the inturn has been almost entirely absorbed, and absorption is still in progress. The inturn is now hardly larger than the normal valvulæ conniventes. The little angular interval, filled by loose fibrous tissue, still marks the suture line externally. Its surface is covered by peritoneal endothelium.

FIG. 279.—Dog 6/23. Axial anastomosis of transverse colon to rectum, after resection of the intervening segment. Microphotograph (×7) of suture line 73 days after operation.

As in the previous specimen, all traces of the mucosal junction have been effaced by reconstructive processes, with the exception of the muscularis mucosæ. The muscular tissue of the inturn is in process of absorption. The inturn is now no larger than the normal mucosal folds of the rectum. Externally, the angular depression, filled by loose fibrous tissue, between the infolded muscular surfaces, marks the anastomosis. Note the recently epithelialized stitch ulcers at the base of the inturned mass, due to a too deeply inserted mattress suture.

employed for suturing. It is noteworthy that the catgut is recognizable in the muscular and connective tissues seventy to eighty days after operation; it is seen to be in process of slow absorption by phagocytic cells (*Figs.* 280, 281). This gives one considerable confidence in employing it alone for all gastro-intestinal suturing, a practice desirable on account of the ultimate absorption of the catgut as contrasted with thread or silk.

It is interesting to note that in the cases of ileocolostomy the mucous membrane of the small intestine within a few millimetres of the junction undergoes a metamorphosis to a colonic type. Its villi are lost, so that its

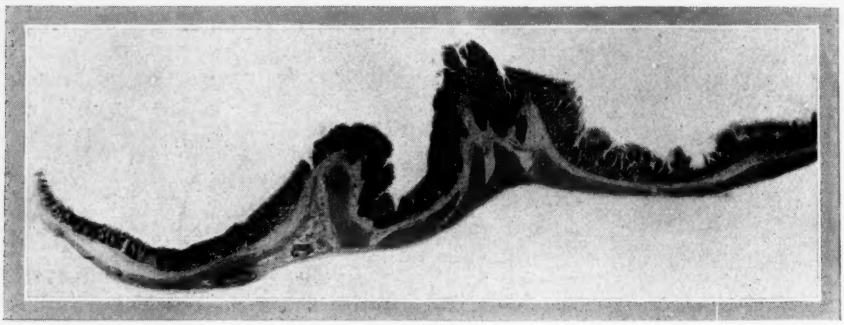


FIG. 280.—Dog 5/23. Axial anastomosis of ileum to transverse colon, after right hemicolectomy. Microphotograph (×7) of the suture line 70 days after operation.

The mucosa is entirely reconstructed, and it is with difficulty that the change in mucosal type, from ileal to colonic, is identified. The gap just distal to the site of junction is a wide gland tubule. Note the loss of villi in the ileum adjacent to the colon (the gland-cells also show metamorphosis to colonic type). The muscularis mucosæ is not yet reconstructed. The inturn is now less in size than the adjacent, normal mucosal fold. Note the catgut sutures, still evident in the subserous tissue.

surface is plain, and only broken by the mouths of the gland ducts and occasional lymphoid nodes. In the gland tubules the ferment-secreting cells are almost entirely replaced by mucous goblet cells. For this reason, even in

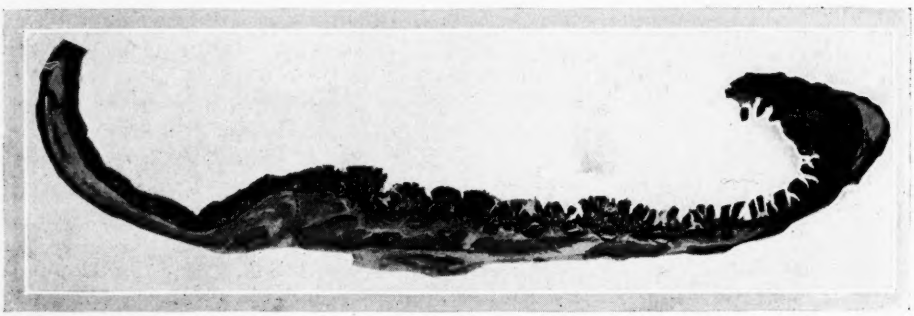


FIG. 281.—Dog 2/23. End-to-side ileosigmoidostomy. Microphotograph (×7) of suture line 78 days after operation.

The mucosal junction cannot be identified with accuracy. The mucous membrane of the ileum adjacent to the colon has the characters of large intestine. The villi are lost, and the gland-cells are of the colonic type. The muscularis mucosæ has been reconstructed. The junction of the muscular coats is now hardly recognizable, as the direction of their fibres has been rearranged and small fibres and bundles of new formation have permeated the loose cellular tissue of the junction. The site of anastomosis is clearly identified externally by the small angular interval between the inturned muscular coats, which is filled by loose fibrous tissue. The peritoneal endothelium smoothly crosses the junction. Note the catgut suture in the muscular tissue to the right of the junction line.

ileocolostomies, it is impossible to identify the mucous membrane junction after about eighty days (*Fig.* 281). A slightly more abrupt change of glandular characters is seen in a 73-day specimen (*Fig.* 280). A similar metamorphosis

of ileal to colonic type of mucous membrane has been described in cases of enterostomy (Holmgren[10]).

The error of permitting even the inner mattress sutures to penetrate to the mucous membrane is demonstrated by the recent stitch ulcers shown in *Fig.* 279. These ulcers are only just healed seventy-three days after the operation, long after healing of the cut edges of the mucous membrane, where the junction is not recognizable. These minute ulcers gave rise to no obvious ill effects in the case shown, but they certainly represent an avoidable imperfection of technique.

Throughout the conduct of these experimental operations we were much impressed with the simplicity of the method and the rapidity with which it could be carried out. The ease and security with which the aseptic ends of the bowel can be manipulated, and the absence of controlling clamps, are especially welcome to the operator when working in a field difficult of access.

THE CLINICAL APPLICATION OF THE METHOD.

The encouragement which the experimental work had given us led us to adopt this method of colectomy in two cases of colon tumour, both of which presented considerable dangers and difficulties if operated on by the usual methods.

Case 1.—Male, age 56. The case came under our care during an attack of acute intestinal obstruction. This was relieved by a temporary cæcostomy, and a large malignant tumour was localized in the splenic flexure of the colon. Twelve days after the preliminary operation the tumour was removed. Owing to its situation and to its extent, it was impossible to apply clamps in spite of the most complete mobilization of the bowel. The ligature method was employed, and the special facility of its application permitted a very complete removal of the affected segment of bowel—in fact, we remarked at the time of operation that only by the ligature method could complete removal be ensured. The resection was carried out on the lines already described, no difficulties of any consequence were encountered, and the further progress was one of an uneventful recovery.

Case 2.—Male, age 65. Subacute obstruction symptoms had developed as the result of a malignant tumour situated at the lower end of the loop of the pelvic colon. The immediate symptoms were relieved by a preliminary cæcostomy, and ten days later the tumour was resected by the aseptic ligature method. The case presented certain aspects which in our opinion made it especially suited for the ligature method. The fixation and the situation of the tumour were such that the use of clamps would have been difficult if not impossible. The patient was in a very debilitated condition throughout the course of his illness, and we felt that any superadded degree of infection, however slight, might easily turn the scale to a fatal issue, and the guarantee therefore of the avoidance of sepsis by the ligature method was a great advantage. With a very slight degree of disturbance the complete excision of the tumour was performed.

Possible Criticisms of the Method.—It is most likely that the criticisms which the method may arouse will take two lines. The fact that the mucous edges are not separately sutured will be objected to for the alleged reason that this delays the process of healing and at the same time encourages infection to pass into the more superficial regions of the suture line. Our results have consistently shown that there is no real danger on this score;

the healing of the mucous edges is early assured, and within a surprisingly short time their continuity is restored. In fact, the experimental studies have already shown that individual suturing of the mucosa is unnecessary, and the operation has been planned upon the recognition of this.

The second criticism will be directed towards the possibility of obstruction developing at the line of anastomosis. It might be imagined that the invaginated cuff of bowel would give rise to obstructive influences immediately after the operation; but the fear has no actual basis in fact. As soon as the ligatures are released, re-canalization occurs, and within twenty-four hours sloughing of the crushed edges further increases the size of the lumen.

Any fears of a late stenosis occurring are dissipated when sections of the anastomosis are inspected. So perfect is the line of union that within seventy-two days of the operation it is very difficult to find the situation in which the anastomosis was completed.

Special Advantages.—The advantages of the method have been so often alluded to during the course of this description that it is sufficient to enumerate the more outstanding ones.

1. Complete asepsis is guaranteed, and numerous associated advantages are therefore obtained.

2. The operation can be performed in situations which are unsuitable for the ordinary methods of clamp anastomosis.

3. The operation is practically a bloodless one as far as the bowel portion is concerned.

4. The operation is completed in a much shorter period of time than is required in the ordinary methods.

SPECIAL NOTE.—Since the foregoing article was written a point has arisen which we consider important to record. In the earliest clinical case which we attempted by the guillotine method, over-anxiety regarding the suture line led us to invaginate a greater amount of the bowel wall than was probably necessary. Seven months after the original operation a second operation was necessary to correct a diaphragmatic semi-obstruction. It is apparent, therefore, that there is a danger in excessive invagination of the bowel wall.

REFERENCES.

[1] PAUL, *Lancet*, 1895, July.
[2] MIKULICZ, *Arch. f. klin Chir.*, 1903, lxix, 28.
[3] POLLARD, *Lancet*, 1904, i, 125.
[4] LITTLEWOOD, *Ibid.*, 1903, May 30.
[5] ROBSON, MAYO, *Ibid.*, 1904, i, 1553.
[6] HARTMANN, *Trans. Med. Soc. Lond.*, xxx, 334.
[7] ANSCHUTZ, *Mitteil. a. d. Grenzgeb. d. Med. u. Chir.*, 1907, Suppl. iii.
[8] FINKELSTEIN, quoted by OPPEL, *Ann. of Surg.*, 1914, lx, 409.
[9] MAYO, *Amer. Jour. Med. Assoc.*, 1906, lxvii, 1379.
[10] HOLMGREN, E., "Veränderungen in der Struktur des menschlichen Dünndarmes an zwei Fällen von angelegten Anus praeternaturalis", *Arch. f. Zoolog.*, 1923, xv, No. 19, 1.

ON THE ORIGIN AND NATURE OF HERNIA.

By Sir ARTHUR KEITH, London.

(Being the Eleventh William Mitchell Banks Memorial Lecture given at the University of Liverpool, November 1, 1923.)

How Mitchell Banks came to Liverpool.—It came about in the year 1869 that Edward Bickersteth, Senior Surgeon to the Liverpool Royal Infirmary, wrote to his old friend and teacher James Syme, Professor of Clinical Surgery in the University of Edinburgh, about two matters which have a particular interest for us on this occasion. In the first place he tells Syme that " he is a firm disciple in the antiseptic theories and practice", and is "lost in wonder and admiration at this great discovery",[1] from which we see that the Senior Surgeon of Liverpool, age 41, had been keeping a close eye on the doings of Syme's son-in-law, Joseph Lister, in the Royal Infirmary of Glasgow. In the second place Bickersteth tells Syme that he needs an assistant. Thus it came about that William Mitchell Banks, age 27, strong in brain and limb, Edinburgh born and bred, but of Liverpool origin on his mother's side, took up his abode in the city which was destined to become the scene of his professional, social, and public achievements. He came to his new home just as the Listerian revolution was breaking. In this movement Mitchell Banks became a standard-bearer. He quickly realized that Lister had opened every region of the human body to surgical enterprise.

His Training as an Assistant.—There is another published letter which throws light on the kind of surgical recruit which Liverpool had thus added to its medical service. It is a letter written by Sir William Mitchell Banks in 1903—the year before his sudden death at the age of 62—to that splendid Lancastrian, Sir William Turner, Principal of the University of Edinburgh, but who, when Mitchell Banks commenced the study of medicine in the autumn of 1859, was senior demonstrator in the dissecting room of Edinburgh University. " I can remember as vividly as possible the day I first saw you, in that terrible old dissecting room at the top of the long stairs. I see John Arthur, with white beard, and spectacles on nose, and a note-book and pencil in hand; I see Stirling with his apron on, peering into a microscope; Cleland is at a desk in a small room off the bone-room; Wilson is warming his back at the fire. You are taking names for 'parts' in a blue serge blouse and with a black velvet cap on your head. I even see that astounding fiend the porter, carrying a body on his back down to the lecture-room. And now you are Principal of the University and covered with distinctions."[2] Here we have more than a vigorous vignette of his studenthood; we realize that in force, ease, and clearness of expression Mitchell Banks rivalled John Hilton, while behind it all is marked that passionate love of the past which many Scots have, and a warmth of heart peculiar to himself, which was one of the great assets of his life.

His Thesis on the Wolffian Bodies.—Sir William Turner has gone; so has the old and intimate friend of Mitchell Banks' student days, Professor John Chiene; but the great anatomist mentioned in this letter, John Cleland, is still with us, as are two contemporaries of Cleland's—Sir James Crichton Browne and Professor W. C. McIntosh—vigorous and alert octogenarians. But in the letter just quoted there is no mention of the greatest figure of all—the tall, sombre master-anatomist, John Goodsir. Mitchell Banks dedicated his M.D. thesis "On the Wolffian Bodies"—a remarkable piece of research for a youth of 22—"To John Goodsir, Esq., F.R.SS. L. & E., with every feeling of respect and gratitude for the many kindnesses which he has shown the author". He loved and worshipped Syme under whom he dressed; for John Goodsir, only 50 years of age in 1864, but moving swiftly to his end, he had a profound respect. We see the influence of the seer-anatomist on this thesis. Our young author, when discussing the reason why the Wolffian body undergoes such a remarkable metamorphosis during development, writes: "The forces which induce these bodies so to act we can evidently know nothing of, connected as they are, in so intimate a manner, *with the original principle of life implanted in the cells which form them.*" John Goodsir must have read this sentence with a peculiar sense of approbation.

His Leanings to Midwifery.—If his thesis was done in Professor Goodsir's rooms, all the needed literature and references were supplied from the Midwifery Department—by Sir James Y. Simpson; clearly the thesis was intended to be a contribution to gynæcology, as if its author had a preference to specialize in this branch of medicine. This, too, was the opinion held by Dr. Matthews Duncan.* But Edinburgh of 1864 had no vacancy for him in either anatomy, surgery, or midwifery, and after a brief adventure in Paraguay, Mitchell Banks became assistant in 1865 to one of the leading anatomists in Europe—Professor Allen Thomson, of Glasgow.† He arrived in Glasgow as Lister began to develop his system; he left that city for Liverpool in the same year as Lister succeeded Syme in Edinburgh.

A Surgeon Anatomist.—Thus we see that the young man who arrived to assist Bickersteth of Liverpool in 1869 was trained, as were most great surgeons until Lister's time, in the dissecting room. Lister killed the surgeon anatomist—or nearly killed him—quite unintentionally. The old surgeon knew nothing of cleanliness, but he did study the machinery of the human body. And now the pendulum has swung to the opposite extreme; the young surgeon of to-day bends his best efforts to become a master of surgical technique, and is careless as to how the human body works. Mitchell Banks was a follower of Lister, but he also remained true to the ideals of the great surgeon anatomists of former times.

The Treatment of Hernia.—In 1876, when Mitchell Banks was appointed assistant surgeon to the Liverpool Royal Infirmary, he was brought face to

---

* A statement made to the lecturer by Professor Rushton Parker.

† After this lecture was set up, I obtained a copy of a valuable semi-autobiographical address given by Sir William Mitchell Banks to the Anatomical Society of the University of Liverpool in 1904, the year of his death. In the preface to this lecture it is stated that he came to Liverpool in 1868 and that his visit to Paraguay took place after leaving Glasgow and before coming to Liverpool. A copy of this address has now been given to the R.C.S. Library by Mr. D. Douglas-Crawford, of Liverpool.

face with an ancient problem: How is a surgeon to relieve that prevalent infirmity of the human body—hernia? At the time of his appointment treatment by surgical measures was in the air: Lister had operated on two cases of hernia in 1871; Czerny was exposing, tying, and removing the peritoneal sac in 1876; very soon afterwards Annandale was operating on cases of hernia in Edinburgh Infirmary. Into this movement Mitchell Banks was drawn, and the treatment of hernia by means of surgical operation became one of the foremost interests of his busy life.

Are Hernias Unduly Prevalent in Liverpool?—I suspect that hernia is unduly prevalent in the city of Liverpool and in the wards of its Infirmary. I find that not only was Mitchell Banks impressed by the magnitude and urgency of the problem,[3] but so also was his colleague, Professor Rushton Parker,[4] who performed his first operation for the cure of hernia early in 1879. At a later date, another Liverpool surgeon, Mr. R. W. Murray, has been impressed by the importance of the same disablement, and his book, *Hernia, its Cause and Treatment* (2nd edition, 1910) represents a very important contribution to our knowledge of hernia. It was at Mr. Murray's suggestion that Dr. Nathan Raw examined the bodies of 200 subjects, both men and women, in Mill Road Infirmary. Although none of the subjects selected was supposed to have suffered from hernia, yet in 47 of them potential hernial sacs were present. From these observations one infers that in every 1000 citizens of Liverpool, past middle age, 230 are the subjects of incipient hernia. Corresponding observations which I made on old people dying in London infirmaries showed that potential hernial sacs occurred less often—namely, about 120 per 1000.

WHY IS A MAN PECULIARLY LIABLE TO HERNIA?

I propose to devote this lecture, given in memory of Sir William Mitchell Banks, not to the treatment of hernia—for such knowledge lies outside my experience—but to attempt an answer to the question: Why should man be the subject of this infirmity so much more frequently than any other animal? As Sir Victor Horsley said in giving this lecture in 1914, the 'radical cure' of hernia is its prevention. To prevent we must first discover the cause, and the first step in any inquiry into the origin of hernia must be an accurate knowledge of its prevalence in our population and exact data as to the time of life at which the ailment first becomes manifest.

The Prevalence of Hernia.—We have now at our disposal certain data which were collected when the manhood of the nation was examined for service during the late war.[5] One of the most reliable sets of observations available is that made by Dr. J. D. Comrie on 10,000 men, between the ages of 18 and 41, recruited in the south of Scotland; 36 men per 1000 were the subjects of hernia. In London and in the S.E. area the number of hernial subjects varied from 17 to 56 per 1000. In one group of Londoners, varying from 18 to 30 years of age, the rate was only 6 per 1000; in those between 30 and 40 years of age the rate was 16 per 1000; in men between 40 and 50 years of age it was 24 per 1000. In a group of men recruited in Manchester and Stockport the rate was 125 per 1000. The result of a comparison of all the data

available leads me to believe that at least 20 out of every 1000 male inhabitants of Great Britain are 'ruptured'.

In order to visualize the problem with which we have to deal, let us confine our attention for a moment to the population of Liverpool—805,000 in number. Let us suppose further that there are 400,000 males, and that the average incidence of hernia—namely, 20 per 1000—holds for Liverpool. This gives us an army of 8000 males in Liverpool alone who are weakened by the presence of a hernia. No survey of women has been made, but the usual experience of surgeons is that hernias are six times more common among males than among females, so that to our army of 8000 males we have to add 1330 females. There must be in Liverpool about 10,000 beings—including babies, boys and girls, men and women—who suffer from hernial defects.

AGE-INCIDENCE OF HERNIA.—If we were to group the 8000 ruptured males in age-periods, as in the following *Table*, we should find that hernia makes its first appearance much more frequently at certain times of life than at others.

TABLE SHOWING THE ONSET OF HERNIA, ACCORDING TO AGE.*

AGE-PERIOD	ONSET PER 1000	AGE-PERIOD	ONSET PER 1000	AGE-PERIOD	ONSET PER 1000
1st year ..	44	21st–25th year ..	30	46th–50th year ..	23
2nd–5th ,, ..	9	26th–30th ,, ..	29	51st–55th ,, ..	17
6th–10th ,, ..	6	31st–35th ,, ..	28	56th–60th ,, ..	14
11th–15th ,, ..	9	36th–40th ,, ..	26	61st–65th ,, ..	10
16th–20th ,, ..	25	41st–45th ,, ..	24	66th–70th ,, ..	6

* This table has been compiled from the following data: (1) It is presumed that the average incidence holds for Liverpool males—namely, that 20 per 1000 are the subjects of hernia; (2) The onset of the hernia in each age-group is based on data contained in that treasury of facts relating to hernia—Macready's *Treatise on Ruptures*—which, although published thirty years ago, still remains the standard reference book in the English language. Allowances have been made for the numbers removed from each of Macready's age-groups by death.

In babyhood, during the first year of life, 44 out of every 1000 babies are hit or crippled by rupture; the incidence is more than double the average rate. Then in the second period of life—from the end of the 1st year to the end of the 5th—there is a partial immunity; the rate of onset drops to 9 per 1000, less than half the average rate. In the third period—from the 6th to the 10th year, there is a further drop to 6 per 1000—the most immune period in a male's life-history. In the fourth, or 11–15 year period, there is a slight rise, but it is not until puberty has been passed that the rate rises markedly; in the 16–20 year period it amounts to 25 per 1000—5 above the average. The second maximum—30 per 1000—is reached by the 25th year; thereafter there is a slight but steady decrease in the liability to hernia until the 50th year is passed. Thereafter men become gradually less liable to the onset of hernia until in the fifteenth age-period—from the 66th to the end of the 70th year—the rate of onset has again dropped to that of childhood. The main fact which such a table impresses on the student of hernia is that the baby sprawling in its nurse's lap, before it has learned to stand upright or to walk, and the young man in the zenith of his muscular development, are the most liable to become the subjects of hernia.

INGUINAL HERNIA OVERSHADOWS OTHER FORMS.—In the above *Table* I have included all kinds of hernia—inguinal, femoral, umbilical, and ventral. But when we look into the proportion in which the various kinds of hernia occur, we see that the central problem is: What is the cause of inguinal hernia? If we take 1000 ruptured males we shall find that in 970 the inguinal region is the site of rupture; in only 20 has the femoral ring given way, and in about 10 protrusion has occurred at the umbilicus. In females the incidence is different. If we take 1000 female subjects of hernia we shall find that 500 are hit in the inguinal region, 340 at the femoral canal, and about 160 at or near the umbilicus. Even in women the inguinal variety is the prevalent type; in males it overshadows all the other forms. Femoral and umbilical hernias in women have a frequency largely in excess of that found in males. When we make all allowances, it will be found that in every 100 cases of hernia dealt with by a medical man in general practice, there will be 90 inguinal hernias, 7 femoral, and only 3 umbilical. The real problem of hernia lies in the inguinal region of the abdomen.

UMBILICAL HERNIA AND THE EVOLUTION OF THE UMBILICUS.—Although umbilical hernia is the least common type, I am to consider it first because it gives us an opportunity of seeing how developmental or evolutionary hernias came into being. The manner in which the umbilicus comes into existence in the human embryo and fœtus is well known; but if we are to understand the processes concerned, we have to descend to a group of animals which lie near the stem from which the higher vertebrates, including man, have been evolved. This group of vertebrate animals includes sharks, rays, and dog-fish—known collectively as selachians. It was the great good fortune of the late Francis Maitland Balfour, younger brother of Lord Balfour, to make the development of the selachian type of fish his special study; it was his great merit to recognize that the processes of development which he saw taking place in them were but simplified representations of the elaborate and obscure processes observed by those working at the development of higher vertebrates such as man. We have therefore to go humbly to the larval dog-fish to understand the origin of the yolk-sac, the placenta, fœtal membranes, umbilicus, and umbilical cord in human beings.

AN UMBILICAL HERNIA IS NORMAL IN LARVAL DOG-FISH.—One of the greatest discoveries made by living tissues in the course of their evolution was the use of capital—the provision of yolk or food on which the larval fish might live while developmental processes were being elaborated. In the embryo dog-fish part of the bowel is prematurely developed to contain the yolk, and before the larval form is ready to take to water, the yolk-sac is contained within a hernial sac formed from the ventral wall of the belly, and lined by peritoneum. As the larval stage is passed and the young fish begins to procure its own food, the whole hernia is gradually and spontaneously reduced and disappears, leaving no scar behind; here we see a hernia being produced and cured as a normal evolutionary event. The occurrence was well known to John Hunter; he also knew that in several types of shark the larval forms were hatched and reared in the Müllerian duct or uterus.

THE SAC OF AN UMBILICAL HERNIA REPRESENTS THE OLDEST FORM OF PLACENTA.—It was the merit of Johannes Müller to carry our knowledge

of the larval dog-fish's umbilical hernia one step further. He found that in certain species where the eggs are hatched and reared within the mother, the wall of the umbilical sac of the larval dog-fish becomes interdigitated with the lining membrane of the womb, and thus the developing animal, in place of being dependent on a hoard of food stored in a yolk-sac, could draw its sustenance from the liquid capital of the maternal body. But for this privilege a price has to be paid; the larval form has to sacrifice that part of its belly wall which, from being a hernial sac, has been converted into a placenta. The placental sac is sloughed as the larval stage comes to a close, just as the antlers of deer are shed in the spring of the year. The point on the belly where the sloughing or necrosis takes place is marked by a wound and scar—the umbilicus.

Congenital Umbilical Hernia.—In the human embryo the hernial umbilical sac is produced so prematurely that we may say it is developed almost before the embryo itself. The placenta and membranes represent an enormously expanded umbilical hernia of the belly wall, and it is at first lined with peritoneum, so that, at an early stage, the serous lining of the sac is infinitely greater than the part which remains within the body of the embryo. The contents of the sac are (1) the herniated fundus of the bladder, known as the allantois, and (2) the yolk-sac. Presently the neck of the hernia contracts and grows in length to form the umbilical cord; the yolk-sac itself goes with the placenta; its neck becomes drawn out into the vitelline duct, while the intestinal loop develops within the expanded neck of the sac. The growing intestinal loop continues in this developmental hernial sac until certain events take place in the opening weeks of the third month of fœtal development.

The Manner in which the Umbilical Hernia of Development is Reduced.—The events which lead to the reduction of the contents of this developmental hernia have been quite recently investigated and described by Professor J. E. S. Frazer.[6] We have to concentrate our attention on the differentiating peritoneum and subperitoneal tissues—particularly on the mesentery attached to the hind-gut. A most orderly developmental or growth movement is seen to take place in various parts of the mesentery; thickenings are being formed along certain lines, adhesions are spreading in several definite directions, and these changes lead to the rotation of the bowels, their attachment in new positions, and the withdrawal of the intestinal loop from the umbilical hernial sac. It is true there are bands of non-striated muscle—such as that of Treitz—in the subperitoneal tissue, but the movements we have been describing depend not on muscular action, but on the mechanical effects which follow the developmental shortenings and lengthenings of the peritoneum. No one who has studied the manner in which the developmental hernia at the umbilicus is reduced can fail to be impressed with the formative properties resident in the fœtal peritoneum and in its underlying tissue.

Healing of the Umbilical Wound.—Within a week after birth the last remnant of the umbilical hernial sac—namely, the cord—has sloughed and a cicatrix is formed round its mouth. No pocket of peritoneum remains, but the site is left with this weakness: within the umbilical scar three cords terminate, derived from the umbilical vein and the two umbilical arteries; and

yet, though no peritoneal pocket is left, we find that the age-incidence—or rather the time of onset—of umbilical hernia runs exactly parallel to that at the inguinal canal. To find a child born with abdominal contents in an umbilical sac is just as rare as to find an inguinal hernia at the time of birth. The umbilicus—and the same is true of the internal abdominal ring—is most liable to be the site of hernia in the first year of life; thereafter during childhood and on to puberty come the most hernia-free years of life. But with full growth and adult womanhood this immunity is lost. We cannot explain the age-incidence of umbilical hernia, as we may inguinal hernia, by supposing the former is due to the presence of developmental peritoneal pockets. When a hernia occurs in the umbilical area, either owing to the weakness of the scar tissue in infancy or to the stretching of the linea alba by obesity or pregnancy in adult life, a peritoneal pocket has to be formed anew.

The Descent of the Testis Represents a Process of Developmental Herniation.—I have dealt with umbilical hernia first and in some detail, because the processes observed make the hernial descent of the testis* a minor and a more easily understood event. The process of extrusion of the testicle pales in importance when compared to the hernial protrusion at the umbilicus, which led on to the formation of the placenta. The extrusion of the testicle represents a comparatively late event in the history of evolutionary changes. It did not come about until the mammalian stem was well under way—when a complete diaphragm had been formed and active movements involving running and jumping were evolved, such movements being necessarily attended by high degrees of intra-abdominal pressure. Why the testis cannot withstand such pressures when it is in a state of active spermatogenesis I cannot tell, but I can offer no satisfactory explanation for its transit to the scrotum unless this supposition is true. In some animals the testes leave the abdomen only when they become the breeding homes of spermatozoa.

Evolution of the Gubernaculum.—It is likely that the initial steps which led on to the descent of the testicle did not take place in the males, but in the females, of early marsupial mammals. Muscular bands descend from the inguinal part of the belly wall to support the pouch or marsupium in which the young are reared. I mention this supposition because in the early human fœtus, and in many other fœtal mammals, long before the descent of the testicle has set in, there is found a strand or cord of tissue issuing from the substance of the groin and passing to the scrotum or labium majus. Cleland named this inguinal strand the 'gubernacular cord'. Unfortunately that most able and lamented surgeon, the late Mr. C. B. Lockwood,[8] mistook this preliminary inguinal strand of tissue for the basis of the real gubernaculum, and built up a theory—which still misleads many surgeons—that the testis is dragged down by muscular cords which are anchored to the scrotum, perineum, and groin. I have no hesitation in saying that John Hunter[9] realized the nature of the process of testicular descent more fully, and gave a more accurate account of the structures concerned, than anyone has done since his time. If I had to add another contribution of more recent date to

* Nearly forty years ago Sir John Bland-Sutton recognized that the descent of the testis represented an evolutionary or developmental hernia.[7]

amplify Hunter's, I would name that made by Mitchell Banks' teacher—the veteran, Professor John Cleland.[10]

How the Descent of the Testis is Effected and a Developmental Hernia Produced.—Every surgeon who has attempted to bring down a testis from the abdomen and place it in the scrotum knows how difficult the operation is. The vas deferens is too short, so are the spermatic vessels, and so is the pocket of peritoneum. Yet by a natural biological process this operation is successfully accomplished during the 6th, 7th, and 8th months of fœtal life in the vast majority of children. At the end of the 4th month of fœtal life we find a plica of peritoneum running from the epididymis and testis down to the future site of the internal abdominal ring. Within the plica are included bundles of fœtal non-striated muscular tissue—so abundant in the subperitoneal stratum of the pelvic region. In the 5th month the plical muscular tissue undergoes a peculiar cellular hypertrophy to form the gubernaculum; the gubernaculum assumes a bulbous form, its thicker end being at its testicular extremity. In the latter part of the 5th and throughout the 6th month of fœtal life the peritoneum, and particularly the subperitoneal tissue, takes on a peculiar form of growth, evaginating the adjacent abdominal wall and apparently pushing its way towards the groin. If in the 6th month one takes hold of the gubernacular bud with a pair of forceps, the slightest degree of pull is sufficient to separate the growing or inguinal end of the gubernaculum and the surrounding hood of peritoneum from the recess it is creating in the groin. All the layers of the belly wall in front of the gubernacular bud are soft, growing, and being evaginated. If we ask how such an effect can be produced, we must attribute it to the influence of the gubernacular bud; such an inference is justifiable when we see the way in which a developing optic cup can cause the overlying ectoderm to form a lens, or the manner in which connective tissue can compel cultures of embryonic epithelium to form tubes.

The Descent is brought about purely by Developmental Changes.—By the 7th month the gubernacular bud and its hood of peritoneum have made their way into the abdominal wall; the testis follows. The gubernaculum retains the same length during the act of transition through the belly wall, this part of the transit occupying the 7th month. Behind the testis a process of growth is at work, elongating the vas, the vessels, and the peritoneum. The gubernacular bud follows the course of the preliminary inguinal strand already mentioned, pressing its nose into the strand. The process of transition is effected entirely by developmental or growth changes of exactly the same kind as brings an abscess, a necrosed piece of bone, or a foreign substance to the surface of the body. It is a process managed, like the retraction of the intestinal loop from the umbilicus, by properties resident in developing peritoneum and subperitoneal tissues. By the 8th month the gubernacular bud has traversed the abdominal wall, and by the 9th it and its hood of peritoneum have established themselves in the scrotum. For some time it will be found that the testis, gubernaculum, and peritoneum can be detached from their hold in the scrotum with the greatest of ease, for they are fixed only by the layer of growing cells. Presently these cells form adhesions, and the gubernaculum becomes reduced to form part of the attachment of the testicle to

its nest within the loose tissues of the scrotum. In the transition of the testes, the gubernacular bud rarely misses its way; it follows the line of the inguinal strand to the fundus of the scrotum; but occasionally it stops short in the groin, or it may overshoot the mark and enter the perineum, or it may turn inwards to the root of the penis or outwards to the thigh.

Healing of the Wound of Transit.—This remarkable and severe operation being completed by the end of the 8th month of fœtal life, there remains a month before birth for the parts concerned to heal up. The neck of the peritoneal diverticulum lying within the freshly formed inguinal canal is new; it has been specially formed during the period of descent; only the fundus of the diverticulum—the tunica vaginalis—is old. Hence we need not be surprised if we find the same changes taking place within the peritoneal funicular process as those we see occurring in the mesenteries of the abdomen during their fœtal fixation. The obliteration of the peritoneal canal proceeds slowly; even in the 3rd month after birth there are still 30 to 40 children in every 100 in whom the upper part of the canal is imperfectly closed.

Why is Hernia most often Produced in the First Year of Life? We have seen that the internal ring is more liable to be the site of hernia in the first year after birth than at any other period of life. We may be inclined to attribute this liability to the tissues of the inguinal region having failed to undergo perfect healing after the severe operation they have experienced to permit the transit of the testis. Man is not alone in this matter; most other mammals have to submit to the same operation, and inguinal hernia is rare in them at every stage of life. Nor can the frequency of hernia in infants be attributed to the patency of the process of peritoneum; this process remains open in nearly all animals—man and the gorilla being exceptional in having it closed. Nor can it be the assumption of the upright posture, for the infant on its mother's lap cannot be described as upright. Nor is it walking, for in the second year the liability to hernia is much less than in the first.

Why does Removal of the Peritoneal Pocket Cure a Hernia? —My friend Mr. Hamilton Russell,[11] and those who believe with him that the presence of a developmental pocket of peritoneum is the sole circumstance which occasions a hernia, will put a very pertinent question to me. They will ask me: Why is it, then, that the removal of such a pocket from the groin of a child cures that child of hernia? My answer is that the operation has done much more than remove a peritoneal sac; it has rendered the sphincteric mechanism of the inguinal canal again competent.* If I put a washer on a leaking tap, I do not claim I have put on a new tap, only made the old one competent. To occlude the mouth of a peritoneal sac is the equivalent

* In the British Journal of Surgery (1923, xi, 148), Mr. Hamilton Russell gives an "internal view after closure of femoral sac by torsion." It will be seen that Mr. Russell has not only removed the femoral sac, but he has very effectually occluded the femoral ring by twisting a plug of peritoneum into it. When consolidated this plug should form an effective barrier against further protrusion of abdominal contents. Mr. Russell relies on an article published by Mr. Allison Panton (*Jour. of Anat.* 1923, lvii, 106) for proof of the congenital origin of hernial diverticula at the femoral ring. If he will read Mr. Panton's article again he will see that Mr. Panton has proved no such thing. Like Mr. Russell, he only hopes the saccular theory is true.

of placing a washer on a tap. The leak in the tap is remedied by tying the mouth of the sac as high as possible. The ligature which is put on, the disturbance which is created in the field of operation, give rise to an inflammatory and healing reaction which consolidates parts round the internal ring. Removal of a sac would be of no avail unless the stopcock mechanism of the groin were efficient. The presence of an open inguinal ring only makes it easier for the bowel or omentum to force the inguinal sphincter—or shutter, as I should prefer to name the structure; but we shall see that there is the most ample evidence that the inguinal shutter can be forced whether there is an open sac or not.

Why, then, is man so much more liable to hernia—particularly to inguinal hernia—than any other animal? It cannot be because his inguinal canal is open; it is his prerogative to have it usually permanently closed; yet he suffers more than animals with the canal permanently open.

THE INGUINAL 'SHUTTER'.—Before returning a definite answer, let us look for a moment at the manner in which man's inguinal canal is guarded. There are two guards, an outer and an inner. The outer guard consists of that part of the external oblique which rises from the 8th, 9th, and 10th ribs, and ends over the flank on each side of the external ring. Every time we stand up, in every effort we make, this muscular guard is set reflexly into action and strengthens the outer wall of the inguinal canal. The inner guard is more complex. It consists, in the first place, of Poupart's ligament, a structure peculiar to man. The essential part of the inner guard is represented by the conjoined muscle—that part of the combined internal oblique and transversalis which, rising from the outer part of Poupart's ligament, passes above the internal ring to end in the conjoined tendon. The tendon of the conjoined muscle is inserted in the crest of the pubis in front of the rectus abdominis muscle. When the conjoined muscle is relaxed there is an interval between its lower border and Poupart's ligament filled by the transversalis fascia and peritoneum. When the muscle contracts, its lower edge becomes pressed against and flush with Poupart's ligament, thus closing the inguinal gap. This is why I prefer to describe the conjoint muscle as a shutter rather than as a sphincter. The underlying mechanism is similar to that which shuts the eyelids, the lower lid, like Poupart's ligament, being almost stationary. If the 12th dorsal nerve is stimulated in the loin, the shutter closes hard down against Poupart's ligament. If we place a finger on the groin when about to cough, we shall feel the shutter close before the expulsive effort is made. If we stand up, we shall feel it tightening and closing in the act of rising. It is worked by a reflex nerve mechanism. Any failure in this reflex will lay the groin open to hernia: who has looked if this reflex is effective or not in the groin of those infants who suffer from hernia? Will not a disturbance along the gastro-intestinal tract inhibit the working of this reflex?

MAN'S GROIN HAS BEEN WEAKENED DURING HIS EVOLUTION.—Man is liable to hernia on account of two circumstances. The first is that the shutter-mechanism of his groin has been weakened by the adaptations his pelvis had to undergo—not for the upright posture,[12] but for his mode of progression. Each step a man takes involves a balancing of his body on the head of one of his thigh bones. In this act the pelvis has to serve as a complex series of short

levers. For this reason his groin has undergone a series of changes; the conjoined muscle has been made less efficient, owing to the necessity of having a Poupart's ligament. The second reason for man's liability to hernia is the fact that he has not only to balance his body on his thighs, but also to maintain his trunk stiff and erect by the action of muscles of his abdominal wall. Over and above this he has become an animal of labour, entailing high and intermittent degrees of intra-abdominal pressure of a kind which are unknown in the bodies of other animals. There is reason to suspect, too, that the reflex muscular mechanism which guards the weak area of his groin may break down. Further on we shall see that it is not continued degrees of high intra-abdominal pressure which cause hernia, but minor and oft-repeated impulses which in time wear down the defences of the groin and pelvic floor and lead to the production of hernial protrusions.

And there is one other matter which requires further observation. We are so apt to look on tendons, fascial structures, and connective tissues as dead, passive structures. They are certainly alive, and the fact that hernias are so often multiple in middle-aged and old people leads one to suspect that a pathological change in the connective tissues of the belly wall may render certain individuals particularly liable to hernia.

The Pulmonary Cavities Represent Interstitial Hernial Sacs.—We have seen that the two regions of the belly wall—the umbilical and inguinal—are the sites of developmental or evolutionary hernia, and that these regions may become after birth the points at which hernial protrusions take place. There is a third site at which herniation occurs as a regular developmental process—namely, the region of the diaphragm. The lung, like the testis, is originally an abdominal organ. The pleural cavities represent hernial diverticula of the abdominal cavity, produced by developmental means.[13] The pleural diverticula, in point of evolutionary history, are older than the scrotal diverticula, but more recent than the umbilical. The umbilical and scrotal are complete hernias, involving all the layers of the belly wall; the lungs, on the other hand, come to lie in an interstitial sac; the diaphragm represents the inner layer of the apical or cervical wall of the primitive abdomen; the pleural diverticula, as they develop, separate the inner or diaphragmatic muscular layer from the neck, and thus it comes about that the lungs lie within an interstitial sac excavated in the cervical wall of the primitive abdomen.

Congenital Hernia of the Diaphragm.—In the course of development the mouth of the pleural diverticulum comes to lie in front of the neck of the 12th rib—its site being marked by the hiatus between the crural and costal fibres of the diaphragm. The mouth of this sac becomes closed by the thickening of the peritoneum at the pleuroperitoneal junction before the end of the 2nd month of development. Here again the plastic properties of the peritoneum secure the closure of the hernial sac.

If the opening fails to close, then the contents of the abdomen grow or are pressed through the pleuroperitoneal passages, compressing the lungs. It is exceedingly rare for a hernia to occur on the right side, for the liver serves to block the passage; but it is otherwise on the left side; hence the usual congenital diaphragmatic hernia lies on the left side, and the protruding

organs are those which occupy the left hypochondrium and umbilical regions of the abdomen. Developmental processes of the liver may grow into the diaphragm, pushing covering sacs in front of them into the pleural cavities or pericardium.

Another and rare congenital opening in the diaphragm—of unknown evolutionary significance—may occur behind the 7th costal cartilage and become the site of a hernia. Another form concerns an apparent hernia of the stomach into the posterior mediastinum. The stomach is originally almost cervical in situation; but as the pleural diverticula expand and the diaphragm descends, the œsophagus becomes elongated, and thus the stomach also descends, maintaining all the way a subdiaphragmatic position. If, however, the œsophagus does not elongate, the descent of the stomach is arrested, and thus we find it placed within the posterior mediastinum surrounded by its sac of peritoneum.* Here the hernial sac is formed, not by a protrusion of the organ, but by the downward movement of the diaphragmatic wall drawing a sac over the stationary stomach. The œsophageal orifice, however, may become the site of a true protrusion of part of the stomach—particularly in cases of visceroptosis. The hernial sac in such cases is not of developmental origin.

For our present purpose diaphragmatic hernias following trauma are not instructive. They represent true 'ruptures'. My friend Mr. David Greig[14] has shown that wounds of the diaphragm do heal, but one may suspect that constant contractions make their sound union difficult and unusual. There are also cases, such as was shown to me by Dr. J. M. Woodburn Morison,[15] where the left dome of the diaphragm was protruded within the thorax so as to form a cup-like hernial sac.

THE PRODUCTION OF HERNIAL SACS AFTER BIRTH.

So far we have been dealing with hernias which occur at sites where processes or evaginations of the peritoneum take place in the development of every child. We are now to pass on to sites where we know for certain that no peritoneal pocket is formed during any date in the development of the human child. These sites are the femoral ring, the obturator canal, and the vaginal passage of the pelvic floor. The last is probably the most frequent site of hernial protrusion to which women are liable. Why, then, are these sites liable to hernia, and how are protrusion of the abdominal contents produced at these points?

Hernial Productions are not Confined to the Abdominal Cavity.—It will assist us to answer these questions if we leave the abdomen aside for a moment and note the manner in which hernial protrusions are produced in other closed cavities of the body. A spina bifida is a hernia of the spinal contents, arising early in fœtal life from an increased pressure in the cerebro-spinal-fluid system. Occipital and frontal encephaloceles are of the same nature; they are localized protrusions of the cranial contents, produced, not

* See J. B. Hume's description of a case in the British Journal of Surgery, 1922, x. 207.

by muscular compression as in the abdomen, but by an increased amount of, and heightened pressure in, the cerebrospinal fluid. We may have a hernia of a contracting muscle, protruding through a defect in its sheath. The most instructive examples, however, are to be found in that series of closed sacs which, linked together, form the alimentary tract.

THE PRODUCTION OF RETROPHARYNGEAL POUCHES.—The most instructive site to study the manner in which hernias of the abdomen arise is the pharynx. A retropharyngeal pouch is a hernial sac developed by repeated pressures out of the lining membrane of the pharynx. It is certainly not of developmental origin. Such pouches are extremely rare under 20 years of age; men and women become most liable to their formation as the age of 40 is approached or passed. They always form at the same site;[16, 17] they emerge from the posterior wall of the pharynx between two parts of the inferior constrictor, the upper or retrothyroid part and the lower or retrocricoid. These two parts of the same muscle serve totally different functions. The retrocricoid or lower part forms a collar round the orifice of the œsophagus, and serves as a sphincter for this orifice. The retrothyroid or upper part of the muscle is the main agent in forcing the swallowed mouthfuls from the pharynx into the œsophagus. Between these two parts of the inferior constrictor there is, when the posterior aspect of the pharynx is examined, a narrow lozenge-shaped area, occupied by smaller bundles of muscular fibres. It is in this lozenge-shaped interval that retropharyngeal pouches begin their protrusion. Professor F. G. Parsons has presented to the museum of the Royal College of Surgeons a specimen—a man's larynx—which shows the first stage in the formation of a pouch.

When a mouthful of food or of drink is transferred from the mouth to the pharynx, a series of events immediately follows. The opening to the larynx is closed; the mouth is cut off from the pharynx; so are the nasal cavities. The constrictors of the pharynx, chiefly the inferior member of the series, seize the bolus; the sphincter to the œsophagus relaxes, and the bolus is forced within the œsophagus and sets out on its journey to the stomach. I have recently estimated the pressure generated within the pharynx as each mouthful is forced within the œsophagus. I found that it was much greater than I anticipated. When the bulbous end of a rubber tube, which is filled with water and connected with a mercury manometer, is swallowed, I found that the pressure generated in the pharynx forced the mercury column to a height which varied between 40 and 50 mm. of mercury above zero. As each mouthful is swallowed, a pressure is generated which will support a column of mercury between 40 and 50 mm. high. The wonder is, not that retropharyngeal pouches occur, but that they do not form more frequently than is actually the case. One might suppose that a delay in the relaxation of the sphincter of the œsophageal orifice would conduce to their production; but were this so we should expect pouches to recur in those cases where they have been removed. This does not seem to happen. I therefore infer that pharyngeal pouches result: (1) From a weakness—perhaps a developmental weakness—in the lozenge-shaped area at the junction of the propelling and sphincteric parts of the inferior constrictor muscle; (2) From the repetition of intermittent impulses of high pressure generated during each act of swallowing, causing

the weak area to stretch and actually grow. The pouch is not formed by a mere extrusion of the lining mucous membrane. At first it has its covering of muscular fibres. The pouch is not a thin and extended slide or avalanche of the lining membrane of the pharynx, but is produced by growth, stimulated by the extruding forces which constantly act on it. Herein we have a demonstration that hernias can be formed and are formed—as a former generation of surgeons believed—by forces acting on a weakened part of the containing wall.

Hernial Protrusion of the Lining Membrane of Various Parts of the Bowel.—*Duodenal Diverticula.*—I need not stay to discuss diverticula which are produced from the œsophagus or stomach, but pass on to those hernial protrusions of mucous membrane of the duodenum which occur so frequently at the point where the common bile-duct perforates its muscular wall. The perforation of a duct through the wall of a closed sac—be it duodenum or bladder—is the weakest point in the wall of that sac. When one thinks of the matter it will be realized that the safe transit of a duct through the muscular wall of a saccular organ is really a difficult problem. Nature has done her best to solve the difficulty by attaching both circular and longitudinal muscular fibres of the bowel to the wall of the perforating duct. Even then the wall of the bowel is weakened at the point of perforation of the duct, and hence hernial protrusions of the mucous membrane of the duodenum occur almost always to the right or to the left or on both sides of the point of perforation. What are the forces or pressures which lead to the formation of these hernial protrusions? Diverticula occur most frequently in cases of visceroptosis, when one may suspect that the exit of contents from the duodenum is rendered difficult by the traction of the superior mesenteric artery. I suspect the stasis in the duodenum is more frequently due to a sphincteric action of muscle at the terminal part of the duodenum. Pockets of developmental origin are exceedingly rare in the duodenum.

Jejunal Diverticula.—Then, in the first part of the jejunum, hernial protrusions of the mucous membrane are not uncommon. They are always produced within the narrow zone to which the mesentery is attached. But their site of origin is not determined by the absence of the peritoneal coat along this zone, but by the fact that it is along this uncovered line that veins emerge and arteries enter and perforate the muscular wall of the bowel. A vein may be engorged one moment and half-empty the next; the point of venous perforation presents a potential space or opening, and it is just at such points that these hernial protrusions of mucous membrane occur. The pressures which generate them are those produced by the strong muscular coats of the wide-lumened jejunum.

Diverticula of the Sigmoid.—Passing next to the most common site of all at which hernial diverticula occur—the sigmoid colon—we are embarrassed by a complete ignorance of the functions carried out by this tract of bowel. We note that the hernial sacs usually occur at the sites of vascular perforation, both at the points where vessels pass to the appendices epiploicæ and along the line of mesenteric attachment. We note that this tract of bowel, when it has become the seat of diverticula,[18] has its interior cut up into a series of communicating cavities separated by inflected semilunar partitions. The

condition of the musculature of the sigmoid or iliac colon, when it is the site of diverticula, leads one to suppose that there has been a disordered action of the musculature—that the iliac colon is broken up into a series of segments each in a state of spasmodic contracture. Diverticula of the sigmoid, like the corresponding pouches in the pharynx, duodenum, and jejunum, do not begin to form until adult life is reached; they are commonest in middle age. In late stages of the disorder pockets will form at other sites than those of vascular perforation. Although we are unable to tell why one person is more liable to diverticula of the sigmoid than another, we cannot overlook the fact that pockets formed in the wall of this part of the colon are of the nature of hernia. The pressure which produces these diverticular hernias is generated by the spasmodic action of the muscular wall of the sigmoid, and the sites of formation are determined by the points of vascular passage.

THE FUNCTIONAL SIGNIFICANCE OF THE CRURAL CANAL AND FEMORAL RING.—Let us now apply the information set out in the foregoing paragraphs to the explanation of hernia at the femoral ring. At no point of the development of man or beast does an evagination of the peritoneum take place at the femoral ring. The formation of a femoral hernia in childhood is exceedingly rare; hernial formations at this site increase in frequency as puberty is passed; they attain their highest incidence of onset about the age of 40. Why is there a femoral ring, and why should man be the only animal which suffers from hernia at this site? The space between Poupart's ligament and the underlying bony brim of the pelvis is divided, as everyone knows, into a larger outer or muscular compartment and an inner or vascular compartment. We have seen that the point at which vessels perforate the muscular wall of a closed sac is a point of weakness; the abdomen is a closed cavity with a muscular wall, and the great iliac vessels perforate its lower wall to enter the thigh. When we stand, particularly if we walk or run, the femoral vein is gorged as it passes under Poupart's ligament; it needs all the available space provided by the vascular compartment; there is then no empty space left—no crural canal or femoral ring. But when we recline and rest, the femoral vein becomes less distended, and there now appears a space to the inner side of the vein, which we call the crural canal; the orifice of this space we call the femoral ring. The crural canal is to permit the femoral vein to enlarge when engorged under the stress of exercise. We have here a safety mechanism, and it is just this mechanism which provides the potential space for hernia.

THE MANNER IN WHICH THE FEMORAL RING BECOMES DISTENDED.—The crural canal just mentioned is of normal size and produced for a physiological purpose. We have now to inquire into the forces which lead to an enlargement of the canal and the protrusion within it of abdominal contents, carrying a sac or diverticulum of peritoneum in front of them. There is no need to analyse the reasons why the sub-Poupartian vascular compartment is relatively large in women; this matter has been investigated recently by Mr. J. Allison Panton.[19] The femoral compartment of women is relatively large: (1) Because of the sexual growth undergone by the pubic part of the pelvis at puberty; (2) Because the iliopsoas of woman is relatively small compared with the size of her sub-Poupartian space.

A consideration of the forces which lead to a pathological enlargement of the femoral ring brings us face to face with the kind of force involved in the production of all kinds of hernial openings of the belly wall. Some years ago I drew attention to the venous cistern from which the heart is filled.[20] The iliac veins form part of this cistern. Through the external iliac veins the venous cistern extends as far as Poupart's ligament. There venous valves are stationed which cut off the femoral veins from pressures generated within the great venous system of the trunk during exercises. We have thus the lower ends of a fluid column of venous blood lying within the vascular compartments at the groin, and filling, when we stand or sit, the potential spaces called the crural canal. Every effort we make compresses* the venous cistern within our bodies, and tends to force the blood into the thighs, which would happen were it not for the sub-Poupartian venous valves. Thus in reality we have lying at the site of femoral hernia a kind of water-hammer; with every effort, with every cough, with every movement of the trunk, the venous column within the vascular compartment undergoes a quick distention, expending a sharp blow on the tissues which surround it—particularly those forming the femoral ring. It is not the steady effort but the repeated impulse, such as occurs in coughing, which leads to the expansion of the femoral ring. The same is true of the veins entering the abdomen from the testicle at the internal abdominal ring; the venous impulse tends to enlarge the orifice.

Fat as a Factor in the Production of Hernia.—We too often forget that fat, in the living body, is a semifluid substance. Its semifluid qualities are used where easy movement of adjoining parts has to be permitted and the generation of vacua prevented. The subpatellar pad of fat sinks into the inequalities of the knee-joint and prevents the production of vacua during the movements of the femoral condyles. The Haversian bursa of fat at the open portal of the hip-joint rushes in as interarticular spaces develop during certain movements of the thigh. The kidneys are surrounded by a peculiarly fluid fat to allow them to swing easily in the respiratory tide. Every subperitoneal pellet of fat represents a miniature water-hammer. We know how they can be forced through vascular foramina in the linea alba under compressive forces generated in the upper part of the abdomen. The peritoneum over the femoral ring has a loose binding, and the subperitoneal tissue there is usually lined with fat, and often a lymphatic gland lies over the ring. Thus at the femoral ring we have the ideal conditions which may lead on to hernia: a potential space for passage of the distended femoral vein; a movable hammer-head represented by subperitoneal pellets of fat; and high intermittent pressures generated in the abdomen during muscular efforts or respiratory disorders. Further, the living pocket of loosely-bound peritoneum carried out as a diverticulum by expulsive efforts is a growing plastic thing; we find that as the fat carrying the pocket is expelled, the mouth of the sac may become narrow or even closed.† I suspect, too, that fluid often

* For a statement of the pressures generated within the abdomen during exercise, see "Visceroptosis", Allbutt and Rolleston's *System of Medicine*, 1907, iii, 860.

† See Mr. McAdam Eccles' *Treatise on Hernia*, 1902.

collects in these pockets as they begin to form, and the presence of fluid serves to increase the hammer effect. How plastic the pockets of peritoneum thus expelled are, and the remarkable forms which they may assume, will be seen from descriptions of femoral sacs given by Mr. Hamilton Russell and Mr. R. W. Murray.

That subperitoneal masses of fat may be expelled beneath Poupart's ligament so as to lie in Scarpa's triangle is well known; my friend Dr. Gladstone[21] has recorded a case where a mass of subperitoneal fat had become herniated into the right thorax through the site of the old pleural passage. The same writer has called attention to the fact that peritoneal diverticula within the obturator canal are carried out during the expulsion of subperitoneal masses of fat.

Herniation of the Bladder.—We see the principle of the water-hammer at work in cases where the bladder becomes extruded as a hernial content. It may pass out at the femoral ring, at the internal abdominal ring, or at the obturator canal, but the most usual site of its herniation is the vaginal passage of the pelvic floor. To permit the easy filling of this organ, the peritoneum is but loosely bound to the anterior pelvic wall and to the regions lying round the sites of femoral and of direct inguinal hernia. The peritoneum is loosely bound in the iliac fossa to permit the movements of the iliopsoas muscles, as well as the filling and emptying of neighbouring visceral structures. When the bladder becomes partly or completely filled with urine, its contents are thrown into impulses with each compressive movement of the abdominal walls. These vesical impulses beat against those parts of the abdominal and pelvic walls with which the bladder lies in contact. These impulses seek out the weak points in the surrounding wall, just as a distended inner tube seeks out and tends to dilate at any weak point in the overlying cover of the tyre. The filled or partly-filled bladder, under the forces generated within the abdomen, becomes a water-hammer hitting against and gradually enlarging the weak places in the containing wall of the pelvis and lower abdomen. It is the defence at the vaginal passage which is usually worn down; it is the repetition of minor strokes which gradually works the damage at hernial sites —not the pressure generated by a great effort—although the latter may often complete the damage and produce the external visible prolapse or hernia.

The Production of Retroperitoneal Hernia.—A consideration of the manner in which retroperitoneal hernias come to be formed within the abdominal cavity brings to light another force which can distend recesses of the peritoneum so that they form hernial sacs. The formation of hernia by the distention of certain peritoneal pockets in and near the roots of mesenteries was dealt with by Sir Berkeley Moynihan nearly a quarter of a century ago.[22] He found, as others have done since, that hernia through the foramen of Winslow and into that great peritoneal pocket which lies behind the stomach is excessively rare. One reason, no doubt, is that there are no knuckles of small bowel in the neighbourhood of the foramen. But why is the hepatic flexure of the colon so rarely thrust within the foramen of Winslow? The reason is that any rise of intra-abdominal pressure acts with just as much force to keep the foramen of Winslow and its peritoneal sac shut as it does to thrust the hepatic flexure into the foramen. If the foramen

of Winslow was situated in the wall of the abdomen and its sac lay outside this cavity, then, on any movement of the body, a hernia would be formed at the foramen of Winslow. The same reasoning holds for all the retroperitoneal fossæ. I look on the duodenal fossa or pocket as serving the purposes of a bursa for the terminal part of the duodenum. If the duodenum has a difficulty in forcing onwards its contents, the duodenal fossa becomes enlarged. It is only a potential fossa as long as the duodenum is active and full. I am convinced that the great retroperitoneal sacs described by Sir Berkley Moynihan and others cannot be regarded as produced by developmental means. What, then, is the force which has led to the expansion of miniature peritoneal recesses into great hernial sacs? There is but one force which could bring about such a result, and that is the pressure exerted by a segment of bowel when it seeks to force its contents forwards against an obstruction. I suppose that a knuckle of bowel during a peristaltic movement forces its convexity into a duodenal or similar fossa, that within the fossa the knuckle is partly occluded, and that the segment of bowel proximal to the entangled knuckle forces in more contents, thus enlarging the pocket. This operation is repeated time after time until a hernial sac big enough to contain the whole of the small bowel is produced. A consideration of retroperitoneal hernia shows us that the peristaltic action of a knuckle of bowel within a small sac may in time make it into a large sac. The bowel, under the force of its peristaltic movements, plays a part in the formation of hernial sacs.

The Frequency of Peritoneal Pockets at the Sites of Hernia in the Aged.—How does it happen that so many people after the age of 40 show one or more peritoneal pockets at the site of the femoral ring, and not infrequently beneath Poupart's ligament to the outer side of the femoral vessels? We saw that in Liverpool Dr. Nathan Raw found in 200 bodies 52 femoral pockets; although not so frequent in London subjects, yet they occur in great numbers. Mr. Murray inferred that such pockets must be of developmental origin to account for the frequency with which they occur. If this were so, those who, like myself, have examined large numbers of fœtuses and children must have come across them. They have never been seen before birth; they become more numerous in each decade of life after the second. Another reason given for believing them to be of developmental origin is that these sacs rarely contain bowel or omentum. They are found to be empty in the dead body. It has been the universal experience of surgeons, as of Mr. Murray himself, to observe that when a patient lies down a hernia in an early stage of formation becomes reduced and its sac empty. The patient has to be asked to cough, or to bear down as at stool, to fill the hernial sac. These pockets observed by Dr. Nathan Raw were incipient hernial pockets; in the supine dead, their contents naturally fell out and they were found empty. If these people had lived and suffered, the contents would in time have filled their sacs and have become irreducible. As I have shown, all the conditions and circumstances needed to give rise to hernia exist within the abdomen of adults; hernia will form in any and every one if there is but a weak enough area in the abdominal wall and a constant repetition of intra-abdominal pressure. The living peritoneum is the most ductile of structures.

HERNIAL POCKETS MAY BE OF DEVELOPMENTAL OR ACQUIRED ORIGIN.—I come now to sum up the inferences which must be drawn from the evidence relating to the etiology of hernia set forth in this lecture. At the present time surgeons hold quite diverse views as to the origin of the peritoneal sac which surrounds a protrusion of abdominal contents. There are those, belonging to the school led by Mr. Hamilton Russell, who maintain that hernial sacs are of developmental origin, that after birth they cease to form, and that if a child, man, or woman, has no pre-formed sac, then one and all of them will be free from hernia throughout their lives. There is the older school, represented by Mr. McAdam Eccles and Mr. Jonathan Hutchinson, who hold that sac formation does not cease at birth but may arise under suitable circumstances at any stage of life. No one who has rightly surveyed the evidence to be gleaned in embryological laboratories, hospital wards, daily practice, and post-mortem rooms can doubt for a moment that these followers of the old school are right. Given a weak point in the abdominal wall, there can be no doubt that the intermittent and repeated forces which are generated within the abdomen of every man and child are sufficient to protrude that weak, but living and plastic, area in the form of a hernial sac. All femoral hernias are produced in this manner; so are all extrusions of the bladder and uterus; and so are all direct inguinal hernias and hernias at the umbilicus; for none of these is there a vestige of reasonable evidence that the sac was formed before birth and by developmental means. As to hernias which escape by the inguinal canal, the evidence is more difficult to decipher; but taking all the lines of evidence into account, one may conclude that most of the hernias of infancy take place into the funicular process, a sac of developmental origin; and that after childhood the sac and hernia are formed together and simultaneously. The fact remains that in many infants hernias do not form althohgh the process is patent, and the same holds true for animals, in which this process remains open throughout life. The presence of a sac is not the essential circumstance which leads on to the formation of hernia.

Bearing of the Theory of the Causation of Hernia on the Workmen's Compensation Act.—The etiology of hernia has an important bearing on the administration of the Workmen's Compensation Act. American surgeons, led by Mr. W. B. Coley,[23] take Mr. Hamilton Russell's point of view, and hold that hernias always descend into pre-formed sacs. The only kind of hernia case entitled to compensation in this Committee's opinion is one in which the protrusion appears suddenly and with pain, and as a result of an accident or of a great muscular effort. There must be proof that the subject was free from hernia before the accident. If the Committee had been logical, it should have made no exception whatsoever.

If the evidence and the inferences as to the origin of hernias put forward in this lecture are right, then by far the greater number of subjects of hernia are properly excluded from recompense under the Workmen's Compensation Act. Hernias which occur in adult men and women are all of them, or almost all of them, of gradual production; repetitions day by day of straining at stool, stooping, lifting, coughing, and all the other bodily movements, cause the semifluid abdominal contents to beat against their containing walls and

gradually to evaginate the weakest points of the abdominal wall. There may be a disorder of the muscular mechanism of the groin—as there often is; the region of the internal ring, or of Hesselbach's triangle, or of the femoral ring, may become distended; the connective tissues may undergo a degenerative change. From bowel trouble or constipation, from respiratory disorders, or from an apparently innocent game of golf, expulsive forces may be generated which give rise in the course of time to hernial protrusions; then a sudden effort, which in a normal man would be harmless, turns a partial or incipient hernia into a real one. It would be unjust if compensation should be paid under such circumstances. And yet it may be just a special effort which a workman is called upon to make which brings about the actual protrusion of contents; if he had not been called on to make a special effort, the strength of his inguinal structures might have served him without accident. I never see a young lad climbing a steep ladder with a heavy sac of corn on his back without feeling that but for the grace of a strong and perfectly competent groin he must quickly become the subject of hernia. So far, inquiries into special trades and occupations, such as gardening, coal-heaving, etc., have failed to give positive evidence that certain occupations are specially liable to cause hernia. Hernia occurs in all classes and at all ages. In the London recruiting returns it is said that 5 per cent of barbers suffer from hernia.

The Importance of a Right Understanding of the Etiology of Hernia.—It is most important that surgeons should form a just and true opinion concerning the manner in which hernias arise. If they occur only in those who have hernial sacs already formed during fœtal life, then we must either excise the sacs at birth or stand by and do nothing but trust to luck. But if the old surgeons such as Mitchell Banks were right in believing that hernias may form at any time of life and are produced by forces generated within the abdomen during efforts, both great and small, and that the occurrence of hernia is due to circumstances over which we have control, then the prevention of hernia is a matter worthy of our serious study. It is for this reason that I have chosen the etiology of hernia as a subject for the Mitchell Banks Lecture.

REFERENCES.

[1] Godlee, Sir Rickman J., *Lord Lister*, 1917, 337.
[2] Turner, A. Logan, *Sir William Turner*, 1919, 77.
[3] Banks, Sir William Mitchell, *Brit. Med. Jour.*, 1882, ii, 985; *Ibid.*, 1887, ii, 1259; *Ibid.*, 1893, ii, 1041; *Medical Times*, 1884, ii, 1171.
[4] Parker, Rushton, *Brit. Med. Jour.*, 1893, ii, 1037; *Provincial Med. Jour.*, 1893, Aug.–Sept.
[5] "Upon the Physical Examination of Men of Military Age", *Reports of the Ministry of National Service*, 1917–1919, vol. i, 1920.
[6] Frazer, J. E. S., *Jour. of Anat.*, 1920, l, 75.
[7] Bland-Sutton, Sir John, *An Introduction to General Pathology*, 1886, 374.
[8] Lockwood, C. B., *Development and Descent of the Testis*, 1888.
[9] *Palmer's Edition of Hunter's Works*, 1837, iv, 1.
[10] Cleland, John, *The Mechanism of the Gubernaculum Testis*, 1856.
[11] Russell, R. Hamilton, *Brit. Jour. Surg.*, 1923, xi, 148; *Lancet*, 1907, i, 683.

[12] KEITH, SIR ARTHUR, Six Lectures on "The Evolution of the Upright Posture", *Brit. Med. Jour.*, 1923, i, 451, 493, 545, 587, 642, 669.
[13] KEITH, SIR ARTHUR, *Jour. of Anat.*, 1905, xxxix, 243; see also *Human Embryology and Morphology*, 4th ed., 1921.
[14] GREIG, DAVID, *Edin. Med. Jour.*, 1919, June.
[15] MORISON, J. M. WOODBURN, *Brit. Med. Jour.*, 1922, i, 90.
[16] KEITH, SIR ARTHUR, *Brit. Med. Jour.*, 1910, i, 301.
[17] MOYNIHAN, SIR BERKELEY, *Lancet*, 1922, i, 1245.
[18] TELLING, W. H. MAXWELL, "Concerning Diverticula of the Sigmoid", *Lancet*, 1908, i, 843.
[19] PANTON, J. ALLISON, *Jour. of Anat.*, 1923, lvii, 106.
[20] KEITH, SIR ARTHUR, *Ibid.*, 1908, xlii, 1.
[21] GLADSTONE, R. J., *Arch. of Middlesex Hosp.*, 1908, xii, 3.
[22] MOYNIHAN, SIR BERKELEY, *On Retroperitoneal Hernia*, 1899.
[23] COLEY, W. B., "Report of the Special Committee on Traumatic and Industrial Hernia", *Ann. of Surg.*, 1922, lxxv, 467.

ACUTE PANCREATITIS.

By H. J. WARING, assisted by H. E. GRIFFITHS, London.

During the past decade a number of patients suffering from acute pancreatitis have come under my care, and upon most of them I have operated and been able to follow the ultimate results. In a proportion of the cases which have recovered, we have also been able to make further observations after the lapse of several years, owing to the fact that further surgical operation has been necessary, post-operative ventral herniæ having developed at the site where a tube or tubes had been left in for the establishment of drainage, or the patients have developed gall-stones or cholecystitis. The series of cases further demonstrates some variations in the clinical and pathological signs and symptoms which are worthy of record. In all, 15 cases have been treated by me during this period.

The term 'acute pancreatitis' comprises several pathological conditions, but in the main the clinical symptoms exhibited are similar and characteristic. Acute catarrhal pancreatitis is described, but, from my experience, if it does not pass into one of the three forms hereinafter mentioned, it is very difficult for the clinician to diagnose it with sincerity.

The forms of acute pancreatitis which come under the observation of the surgeon are three: (1) *Acute hæmorrhagic pancreatitis*; (2) *Acute gangrenous pancreatitis*; (3) *Acute suppurative pancreatitis.* The third variety, however, would appear to be a later stage, localized and very virulent, of the first. In its most acute form, the affection is one of the most serious diseases which the surgeon is called upon to treat, and if a reasonable amount of success is to be obtained it is very essential that early diagnosis be made and immediate treatment carried out.

Symptoms.—

1. *Acute Abdominal Pain.*—Pain, referred to the epigastrium or the adjacent portion of the abdomen, may be so acute and sudden as to cause immediate collapse, and is usually the first symptom noticed. In *Case* 10 the patient—a clerk employed in the City—came up by train in order to attend his ordinary occupation, and as he was walking from the station to his office he was suddenly seized with violent abdominal pain (which he referred to the epigastrium), which caused him to collapse on the pavement after clinging for a brief period to some adjacent railings; whilst in *Case* 6 a lady attended a garden party one afternoon, and when walking home was seized as she was crossing a lawn with violent abdominal pain referred to the epigastrium and right hypochondrium. She collapsed, and had to be taken home in a vehicle. These two cases represent the most acute form of onset; in others the abdominal pain had not such an acute onset, but in all it was severe. Within a few hours of onset pains are almost invariably felt in the upper

region, either on one or both sides. This spread of the pain to the lumbar region, when taken into consideration with other clinical signs and symptoms mentioned later, is almost pathognomonic of the affection.

2. *Vomiting.*—This is a fairly constant symptom during the onset of the disease, but it is not invariable, and there may be merely nausea. The ejecta are the contents of the stomach and bile; I have not seen any patients in whom blood has been met with, although it is stated by some observers that this does occur.

3. *Rigidity of the Abdominal Wall.*—This is not usually a marked sign during the onset of the disease, although deep-seated tenderness with slight overlying rigidity may be elicited on pressure in the epigastric region. The majority of patients who are the subjects of acute pancreatitis are very obese; consequently the detection of deep-seated tenderness is not always easy. When the disease is well established and septic peritonitis has developed, then there may be general abdominal rigidity, but this is not constant. In *Case* 4, in which the disease was of five days' duration, the abdomen was quite soft, although the patient was almost moribund from toxæmia, and the general peritoneal cavity contained a considerable quantity of blood-stained serous fluid and there were extensive areas of fat necrosis.

4. *Temperature and Pulse.*—Immediately after the onset the pulse is rapid and weak, but later it becomes fuller, especially when the temperature is raised. The temperature is at first subnormal and then raised, but generally not more than 101° or 102°.

5. *Cyanosis and Jaundice.*—In the very acute cases cyanosis of the face and extremities is generally a characteristic sign. Some observers have also detected it in the abdominal wall, but I have not met with it in this region. When present and associated with acute abdominal pain most marked in the lumbar region, it may be looked upon as almost pathognomonic of acute hæmorrhagic pancreatitis. In the less acute cases a slight icteric tinge of the skin and membranes may be noticed, and bile detected in the urine. There may also be dyspnœa or difficulty in breathing. This combination of cyanosis and difficulty in breathing was very marked in *Case* 13.

6. *Localized Abdominal Swelling.*—Occasionally a distinct swelling can be felt in the epigastric region lying transversely and in the normal position of the pancreas, with normal stomach resonance in front of it; whenever the patient suffers from gastroptosis this swelling can be felt immediately behind the anterior abdominal wall and below the liver. Owing, however, to the general obesity of the patients, it is difficult to detect any definite swelling; but if they happen to be sparsely covered it may be felt, as in *Cases* 5, 8, and 9. In the less acute cases which have become suppurative, a swelling can almost invariably be detected on palpation.

7. *Diastase in the Urine.*—Normal urine contains 10 to 20 units of an amylolytic ferment—diastase. In disease of the pancreas associated with pancreatic insufficiency, this diastase may amount to 100 or 200 units, or even more. Many cases of acute pancreatitis reveal this increase of diastase, but in the very acute cases sufficient time has not always elapsed between the onset of the disease and the examination of the urine to enable it to be manifest. This is especially the case in the acute hæmorrhagic type; the acute

gangrenous and suppurative types almost invariably show excess of diastase (*Cases* 8, 13, and 15).

8. *Adrenalin Mydriasis Test.*—A test known as Loewe's adrenalin mydriasis test is considered by some observers to be of value in the diagnosis of pancreatic disease. The test is carried out by dropping two drops of 1–1000 adrenalin solution into one conjunctival sac, a proceeding which is repeated after an interval of five minutes. If at the expiration of thirty minutes dilatation of the pupil is noticed, then the test is considered positive and pathognomonic of pancreatic disease. The other eye is used as a control in the observation. Our experience in the series of cases quoted later is that the test has been positive in three out of four cases.

9. *Glycosuria.*—Sugar in the urine has been detected in a small number of cases of acute pancreatitis, but it is far from constant, and when occurring is often transient. One patient whom I saw with the late Mr. Lockwood was a man of 29 who suffered from acute abdominal pain located above the umbilicus. He was at first considered to have acute appendicitis, but a large amount of sugar was detected in the urine, and on this account acute pancreatitis was suspected. Since this quickly disappeared, the diagnosis of appendicitis was reverted to, and an operation performed for the removal of the appendix. This was found to be normal. Blood-stained fluid was present in the peritoneal cavity, and the cause of the symptoms was found to be acute hæmorrhagic pancreatitis. This patient survived the operation for a few days only, but sugar did not reappear in the urine.

The three preceding signs—diastase in the urine, adrenalin mydriasis, and glycosuria—are fairly constant in chronic pancreatitis, and are of considerable importance in making a diagnosis; but in acute pancreatitis, especially the fulminating forms, their absence cannot be considered as contra-indicating the existence of pancreatic disease, and their presence merely confirms the clinical diagnosis from the other signs and symptoms. Cammidge's pancreatic test, in my experience, is of no value in the diagnosis of acute pancreatitis.

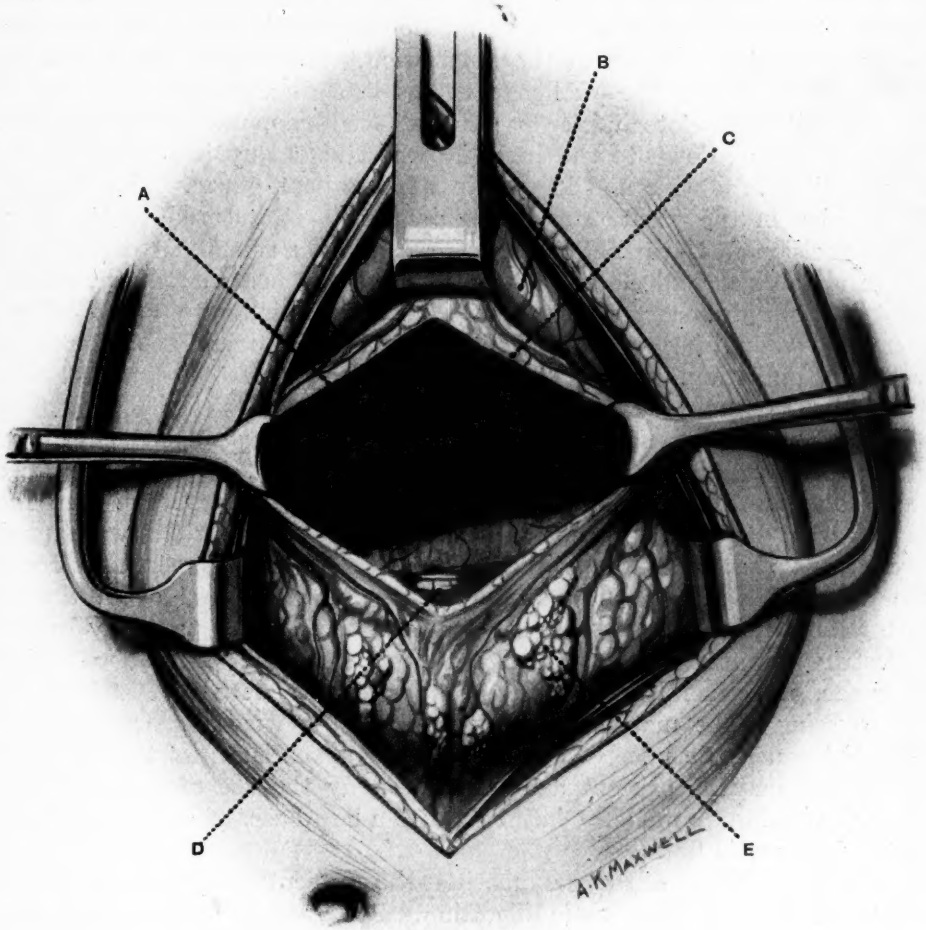
Diagnosis.—The acute abdominal affections which in some respects show various signs and symptoms comparable with those of acute pancreatitis are: (1) *Acute appendicitis*; (2) *Perforation of a gastric or duodenal ulcer*; (3) *Biliary colic*; (4) *Acute intestinal obstruction*, such as that met with in volvulus, strangulation by a fibrous band, Meckel's diverticulum, or an internal hernia.

Careful attention to the position of the pain and its mode of onset and its tendency to become marked in the lumbar region, comparative softness of the abdomen in the early stages, toxæmia and cyanosis, increased diastase in the urine, occasional glycosuria, and slight jaundice or icteric tinge, will usually enable the clinician to make a diagnosis. Cases, however, occur in which the signs and symptoms are not sufficiently pronounced at first, or their character has been altered by the previous administration of morphia, so that an exploratory operation is necessary before a correct diagnosis can be made.

Course of the Disease.—Unless treated by prompt surgical measures, acute pancreatitis is rapidly fatal, from two to five or six days being the

ordinary duration. In some cases an abscess may form, in which event the duration is longer (*Cases* 8 and 9).

Treatment.—Whenever acute pancreatitis is either diagnosed, or from the signs and symptoms reasonably suspected, immediate operation should be recommended. The sooner this can be done after the onset of the affection the greater are the chances of recovery. The greater sac of the peritoneum



FIG, 282.—Acute pancreatitis. A, Hæmorrhagic pancreas. B, Stomach. C, Gastro-colic omentum incised vertically. D, Lesser sac and blood-stained fluid therein. E, Area of fat necrosis.

is opened by an incision a little to the right of the medial line, commencing in the epigastric region and extending below the umbilicus. Since most of the patients are obese, an incision of 5 inches (12 cm.) or more is generally necessary. Usually, on opening the cavity of the peritoneum, blood-stained fluid will be met with; but in early cases this is limited to the lesser sac, in which case red-coloured fluid will be visible in the great omentum immediately

below the greater curvature of the stomach. This appearance is well shown in *Fig.* 282. In addition, white areas of fat necrosis may be seen in the omentum and exposed peritoneum. When dealing with a case of doubtful diagnosis the presence of areas of fat necrosis and blood-stained serous fluid in the peritoneal cavity may be regarded as pathognomonic of acute pancreatitis. Complete exposure of the pancreas is usually effected by dividing the anterior two layers of the great omentum immediately below the greater curvature of the stomach, separating the margins of the incision, and lifting up the stomach towards the lower margin of the thorax. The appearances then presented are shown in the illustration. After exposure, free incisions should be made into the swollen pancreas in a direction parallel to its long axis, and all blood-clots and serous fluid removed by sponging. Large drainage tubes are passed down to the incised area, and the region of the pancreas is packed with a wide and long strip of absorbent gauze. The margins of the incision in the great omentum should next be sutured to the margins of the incision in the parietal peritoneum, and the remainder of the incision in the abdominal wall closed. On account of the necessity of the establishment of free drainage, post-operative hernia is liable to occur after the operation wound has healed. This, however, can readily be cured by a secondary operation. (*Cases* 1, 7, and 12.)

After-treatment.—

Drainage.—It must be remembered that during an attack of acute pancreatitis large portions of the organ are destroyed, and that sloughs continue to separate for many weeks after the original operation. In *Case* 1 sloughs were discharged for nine months. In *Case* 15 the tubes were removed three weeks after operation, and a second attack of acute pancreatitis occurred two days later. A second operation was performed, and again the tubes were removed after two weeks, only to be succeeded the next day by severe epigastric pain and vomiting. The tubes were again introduced into the lesser sac, and several small pancreatic sloughs evacuated.

Dressing.—The material discharged from the wound generally contains activated pancreatic juice, which causes severe excoriation of the surrounding skin. This may be prevented or minimized by the use of a heavy mineral oil—e.g., paraffinum molle. Ointments with a lard base, of course, are digested by the pancreatic fluid.

Feeding.—After acute pancreatitis the patients waste rapidly, owing largely to lack of pancreatic digestion. Feeds must be frequent, and in the early stages should all be pancreatized. Until the diastase content of the urine has fallen to normal, fats should be almost entirely withheld and then should be given sparingly and never allowed to accumulate in the stools.

Morbid Anatomy.—In the first stage of acute pancreatitis the head of the gland becomes swollen and pink, and its peritoneal surface shiny and tense. The swelling rapidly spreads along the body of the organ until two-thirds or more may be involved. A little serous peritoneal exudate may be observed, but fat necrosis is not found at this stage. The next stages occur very rapidly: first, softening in the region of the head, and then sudden hæmorrhage ploughing up the gland tissue and causing a large dark swelling

(*see* ***Fig.*** 282); the blood may infiltrate between the layers of the transverse mesocolon into the root of the mesentery or into the retroperitoneal tissues of the posterior abdominal wall. In some cases the hæmorrhage remains localized; in others it bursts through the serous covering into the lesser or greater sac, or both, producing the most acute symptoms of 'perforation of the pancreas'. In the hæmorrhagic stage fat necrosis is found. With the progress of the disease, pancreatic juice is mixed with the blood, producing alteration in the character of the exudate, which becomes chocolate-coloured and often foul-smelling from secondary infection. General peritonitis supervenes, and unless drainage is established death occurs.

Large areas of the pancreas become necrosed and are extruded as putty-like sloughs; occasionally the whole of the gland has been sequestered as a slough, either through a drainage wound or the rectum (Dever and Chiari). In cases where the hæmorrhage remains confined in the peritoneal capsule of the pancreas (gangrenous pancreatitis), secondary infection occurs later, with the production of a localized abscess (suppurative pancreatitis). The disease then runs a much more chronic course.

It is our belief that all cases of acute pancreatitis are due to infection; therefore the old theories of pancreatic apoplexy will not be considered in this paper. The infecting organism is nearly always the *Bacillus coli communis* (*Case* 8), but occasionally streptococci may also be found. It is not unusual to find that the material removed at operation is sterile (*Case* 11), probably because the activated pancreatic ferments have killed off the bacteria. There are several routes by which infection may reach the pancreas, and it seems likely that more than one of them may be used by the organisms in different cases. There seems little doubt, however, that the primary source of infection is generally the gall-bladder or the duodenum. In the main, infection is spread from these organs to the pancreas by the lymph vessels or by the pancreatic or common bile duct. The majority of the efferent lymph vessels of the gall-bladder pass to a lymph gland situated at the junction of the neck of the organ with the cystic duct; they then pursue a course down the common bile-duct, interrupted by several lymph nodes, finally reaching the back of the pancreas before termination in the anterior aortic group of lymph glands.

In two-thirds of the cases the common bile-duct is embedded in the substance of the head of the pancreas, and the efferent lymph vessels of the gall-bladder accompany it. In this position the vessels are brought into intimate relation with the lymph vessels of the head of the pancreas, and in fact have many and free communications with them. Infection, therefore, brought from the gall-bladder may readily cause a pancreatic lymphangitis, the starting-point of acute pancreatitis.

The lymph vessels of the first and second part of the duodenum have a similar but less intimate connection with those of the head of the pancreas.

Retrograde infection along the pancreatic ducts by bile is probably a less common cause than lymphatic infection, but its occurrence has been definitely proved. In *Case* 15, an illustrated plate of which accompanied our article in Gask and Wilson's *Surgery*, 1920, three gall-stones were demonstrated impacted in the ampulla of Vater; the main pancreatic ducts and much of the glandular

tissue were deeply stained by bile. On examining a microscopic section of the organ it was found that even the minute ducts and acini contained bile pigment. Only in one case, however, have we found definite evidence of obstruction in the ampulla of Vater, or of regurgitation of bile, although jaundice has been present in seven cases. It is possible that spasm of the muscle surrounding the ampulla (Oddi's sphincter) may cause a transient regurgitation of infected bile which is not sufficient in quantity to stain the body of the pancreas.

We have no case to prove that infection ever occurs directly from the duodenum along the pancreatic ducts. Our work tends to show that the duodenal contents are sterile, or nearly so, and that micro-organisms never exist there in sufficient numbers to make invasion of the pancreas likely or formidable.

Normally, the pancreatic juice is not activated until it reaches the intestine. If, however, trypsinogen be converted into trypsin in the ducts or substance of the organ, rapid destruction of tissue must be expected, producing a condition so like an acute gastric ulcer that Mayo has spoken of it as 'perforation of the pancreas'. Activation of trypsin within the gland is the predominant factor of acute hæmorrhagic pancreatitis. A number of reagents found in the body other than enterokinase can activate trypsinogen, chief amongst them being blood, infected bile, degenerate leucocytes, and certain bacterial toxins.

Archibald, supported by Dever, is satisfied with the theory of retrojection of bile consequent upon spasm of the sphincter of the ampulla of Vater as the cause of the onset of the disease. This theory, however, does not explain the fact that the destruction of the pancreas is sometimes patchy, with isolated areas of sound pancreatic tissue showing signs of inflammation or of bile staining. It seems to us more likely that the activating agent in the majority of cases is blood. The first step in an acute inflammatory condition is the congestion of the pancreas and the production of small hæmorrhages. The majority of these occur in the interstitial tissue, but some occurring in the alveoli activate pancreatic juice, and local auto-digestion begins, which soon opens a small vessel providing more blood to activate the trypsinogen, and a vicious circle is produced, quickly resulting in the destruction of large areas of tissue.

Fat Necrosis.—Fat necrosis occurs in all cases of acute pancreatitis. It may be widely distributed over the peritoneum, but is most plentiful in the transverse colon, the root of the mesentery, and the great omentum. From its distribution its origin was held to be due to the local action of escaped pancreatic juice, and this view is still widely held; but in a few cases the change has been found in the pericardial fat and the extrapleural fat, places which cannot possibly have been exposed to the direct action of the fluid. It seems, therefore, that the occurrence of fat necrosis may be attributed also to ferments liberated by the diseased pancreas and circulating in the blood. At autopsies we have made careful search in the fat of other regions—e.g., subsynovial—but have not found fat necrosis outside the abdomen and thorax.

Summary of Cases.

Case	Age	Sex	Pain		Vomiting	Cyanosis	Jaundice	Soft Abdomen	Swelling	Sugar	Diastase	Loewe	Gall-stones	Fat Necrosis	Result
			Abdomen	Lumbar Region											
1 ..	40	M.	+	+	+	+	+	+	+	/	/	/	O	+	R.
2 ..	40	M.	+	+	O	O	O	+	+	Not ex. Later 0	Not ex. Later 10		O	+	R.
3 ..	77	M.	+	+	+	+	+	+	O	++	250	/	O	+	R.
4 ..	63	F.	+	+	+	++	+	+	O	/	/	/	/	+	D.
5 ..	60	F.	+	+	+	+	+	+	O	/	/	/	O	+	D.
6 ..	54	F.	+	+	+	++	+	+	O	/	/	/	O	+	D.
7 ..	40	F.	+	O	+	O	O	O	O	/	/	/	O	+	R.
8 ..	55	M.	+	O	+	/	/	+	+	O	200	+	O	+	D.
9 ..	50	M.	+	+	+	+	O	+	+	+	/	/	O	+	D.
10 ..	42	M.	+	+	+	O	+	+	O	O	/	+	+	+	D.
11 ..	44	M.	+	O	+	O	O	O	O	O	/	/	O	+	R.
12 ..	57	F.	+	+	+	+	O	+	O	O	200	O	O	+	R.
2nd attack	59	F.	+	+	+	+	O	+	O	+	128	/	O	+	R.
13 ..	38	M.	+	O	O	++	O	+	O	++	200	/	O	+	D.
14 ..	46	M.	+	/	/	/	/	/	/	/	/	/	+	+	D.
15 ..	42	F.	+	+	+	O	+	+	O	O	100	—	O	+	R.

+ = Present. O = Absent. / = No examination made or recorded. R = Recovered. D = Died.

LIST OF CASES.

Case 1.—March 25, 1911. Gentleman, age 40. After watching 'Varsity sports in a snow blizzard, returned home at 5.45 and took tea. One hour later had pain in the small of the back radiating up to both shoulders. This increased until 1.30 a.m., when it was relieved by drinking brandy and hot water.

March 29. Similar pain, relieved by brandy.

March 30. Awoke feeling well and hungry; good breakfast; felt dull about 10.30; continued working; 11.15, vomited. No nausea or retching.

March 31. Felt better, noticed bile in urine. Took seidlitz powder, but bowels were not opened; 10.30, 'felt dull'; 11.15, vomited; 11.25, first noticed yellow appearance of eyes and face; was seen by doctor and sent to bed; 3.45, severe abdominal pain commenced; 5.30, fainted. From 10·40 pain increased steadily until morphia ½ gr. was administered and patient went to sleep.

April 1. Dozed nearly all day. Pain severe when conscious; great thirst.

On examination, the patient was found to be a very fat man. He was definitely jaundiced and slightly cyanosed. The abdomen was soft and moved with respiration, but on palpation a swelling could be felt, starting in the epigastrium in the mid-line and extending to the left. The swelling was dull on percussion, the stomach resonance being made out below it. Immediate operation was advised.

Operation.—An incision was made over the swelling just to the right of the mid-line. On opening the general peritoneal cavity a reddish-blue swelling could be seen pushing forward the gastro-hepatic omentum and displacing the stomach downwards. The gall-bladder and ducts were palpated and no stone was felt. A *transverse* incision was then made through the small omentum, and the lesser sac found to be filled with blood-clots and pus, which were evacuated. The pancreas was swollen and soft in places, and was incised in its long axis. There were patches of fat necrosis in the transverse mesocolon. A large drainage tube was passed down to the pancreas, and the abdominal wound partially closed.

The patient's convalescence was slow. Pancreatic sloughs continued to be discharged for nine months after the operation, but he ultimately made a complete recovery. He again came under observation ten years later—in 1921—when he was operated upon for repair of a post-operative ventral hernia. At this time he was a healthy man, with no evidence of pancreatic disease. The urine contained 10 units of diastase and no sugar.

Case 2.—Gentleman, age 40. For eight days had vague abdominal discomfort which was associated with indigestion and flatulence, and then was seized with an acute attack of abdominal pain of such severity that he fainted. On examination, he was seen to be a moderately fat man suffering from severe shock. His face was pale and sweating, but there was no noticeable cyanosis. Pain was referred to the epigastrium and the lumbar region. The abdomen moved well on respiration, and was soft. A transverse swelling could be made out, situated deeply in the abdomen behind the gastro-hepatic omentum. The swelling did not move on respiration, and was dull on percussion, the stomach resonance being identified below. The temperature was subnormal, and the pulse 130. A diagnosis of acute pancreatitis was made and operation advised.

Operation.—An incision 4 in. long was made in the mid-line in the epigastrium, and the peritoneal cavity opened. Patches of fat necrosis were noticed in the great and small omentum and in the transverse mesocolon. The lesser sac was explored through the gastro-hepatic omentum, and found to contain a little blood-stained fluid. The pancreas was very swollen, and appeared bluish beneath the peritoneum. An incision was made through its serous covering, starting over the head and continued along the long axis of the organ to the left extremity of the swelling. Much blood-stained seropurulent material was evacuated, and some blood-clots. A large red rubber drainage tube was passed down to the pancreas through the small omentum, and the abdomen closed.

The patient made an uninterrupted recovery, but during convalescence several putty-like sloughs were discharged through the drainage tube. A post-operative

ventral hernia was repaired in 1920. At this time the patient appeared perfectly well, and there was no evidence of any pancreatic disturbance. The urine contained no sugar and 10 units of diastase. At operation the pancreas felt normal, but the lesser sac was not opened to inspect it.

Case 3.—Gentleman, age 77. Was seized with acute abdominal pain referred to the epigastrium and lumbar regions. Vomiting was severe, but shock not a marked symptom. On the following day he was brought to London, and on examination found to be slightly jaundiced and definitely cyanosed. The abdomen moved on respiration, and was soft, but no swelling could be felt. Temperature, 103°; pulse, 120; respiration, 30. Urine: sugar; diastase, 250 units. A diagnosis of acute pancreatitis was made.

OPERATION.—Operation was performed immediately. The abdomen was opened through a mid-line incision above the umbilicus, and patches of fat necrosis were noticed in the great omentum. The lesser sac was explored through an incision through the anterior two layers of the great omentum about three inches below the greater curvature of the stomach. A bluish swelling was seen in the position of the head and proximal portion of the body of the pancreas. This was incised along its longitudinal axis, and clots and blood-stained material were evacuated. No stones were palpated in the gall-bladder or bile-passages. The pancreas was drained through two rubber tubes, and the abdominal wall closed. Recovery was uneventful.

Case 4.—Woman, age 63, very fat. Had had severe abdominal pain for three days which had been diagnosed as subacute appendicitis. On examination, she was deeply cyanosed and slightly jaundiced. The abdomen moved feebly with respiration, and was soft. The pulse was almost imperceptible. A diagnosis of acute pancreatitis was made, but she was too ill to stand operation, and died two hours later. A post-mortem examination showed acute hæmorrhagic pancreatitis involving the head and practically the whole body of the gland.

Case 5.—Lady, age 60. Had had vague abdominal pains and constipation for three days, and had been treated for chronic intestinal obstruction. On the fourth day she was much worse, with very severe lumbar pain and intense vomiting.

On examination, she was found to be slightly cyanosed and slightly jaundiced. The abdomen moved feebly on respiration and was soft. There was marked tenderness above the umbilicus and in the lumbar region. The temperature was 101°, the pulse feeble and irregular.

A diagnosis of acute pancreatitis was made, and operation not advised because of the enfeebled condition of the patient. Later, after consultation with three other surgeons, the pancreas was rapidly explored and drained; but the patient did not rally, and died on the following day.

Case 6.—Lady, age 54, very stout. Had had several attacks of abdominal pain and vomiting during the past few years which had been diagnosed as biliary colic. Whilst crossing a lawn at a garden party she was seized with violent abdominal pains and collapsed; she was taken to the house and seen early the following morning. She was a very fat woman—20½ stone; was deeply cyanosed and slightly jaundiced. She had severe pain and tenderness above the umbilicus and in the lumbar region. The abdomen moved on respiration and was soft, but no swelling could be palpated through the fat. Temperature 99°, and pulse feeble and uncountable. A diagnosis of acute pancreatitis was made.

OPERATION.—At 9 a.m. the abdomen was opened through a mid-line incision, and fat necrosis noted scattered throughout the subperitoneal fat. There was much blood-stained fluid in the greater and lesser peritoneal sacs. The pancreas was explored through the anterior two layers of the great omentum, and was found to be almost completely destroyed by extensive hæmorrhagic extravasation. A large red rubber drainage tube was introduced into the lesser sac and one into the greater sac, and the abdomen closed. The patient died on the following day.

Case 7.—Lady, age 40. Had indefinite abdominal pain which gradually became more acute and localized in the right hypochondrium. Vomiting became severe, but there was no cyanosis and no jaundice. The abdomen moved slightly on respiration, and there was resistance to pressure in the upper part, more pronounced on the right. A diagnosis of biliary colic was made.

Operation.—The abdomen was opened through a vertical incision to the right of the mid-line. When the peritoneum was opened, fat necrosis was observed in the great omentum, and the pancreas could be felt to be much swollen. No gall-stones could be palpated in the gall-bladder or biliary passages. The lesser sac was explored through the anterior two layers of the great omentum, and a blue swelling was observed in the proximal part of the body of the pancreas. This was incised in its long axis, and blood-clots and blood-stained fluid were evacuated. A large red-rubber drainage tube was passed down to the diseased area of the pancreas, and the abdominal wall closed. The patient made a good recovery, but later came up for repair of a post-operative ventral hernia. The opportunity was taken to explore the pancreas, which was apparently normal. The urine examined at the time showed 10 units of diastase and no sugar.

Case 8.—Man, age 55, ventriloquist. Admitted to St. Bartholomew's on June 12, 1913, complaining of abdominal pain and vomiting. For three weeks before admission, patient had had very severe attacks of vomiting. On June 10 he became worse and vomited incessantly. The stools were pale in colour at first, and then for a week were 'very black, like congealed blood'.

On admission to the hospital he was a well-nourished man. Tongue very heavily coated. Chest, nothing abnormal discovered. The abdomen moved well on respiration. It was soft on palpation except in the right hypochondrium, where there was some tender resistance. Over this area there was an impairment of the percussion note which was continuous with the liver dullness. A lump could be felt in the epigastrium, but its limits could not be clearly defined. It did not move on respiration. The knee-jerks were absent. Urine: acid; albumin + + ; blood 0; sugar 0. Loewe reaction +.

Operation, June 14.—Laparotomy, mid-line incision, and drainage of lesser sac. No fat necrosis was seen and no gall-stones were found. The lesser sac was explored through the transverse mesocolon, and found to contain blood-stained fluid. The head and body of the pancreas were hard and enlarged to about the size of a Tangerine orange. Its centre was deeply excavated, and extensive hæmorrhage had taken place into it.

Pathological Reports.—Fluid from peritoneal cavity: sterile. Fluid from pancreas: pure growth of *B. coli* June 16. Urine: diastase 200 units, no sugar, urobilin +, glycuronic acid +. Cammidge's reaction negative after forty-eight hours. Fæces: no excess of fat. Vomit: acid, blood, bile. Loewe's test, +.

On June 21 several sloughs were washed out through the tube. On June 24 patient collapsed suddenly, and died the next day.

Post-mortem.—Lesser sac contained masses of necrotic tissue and pus. A large portion of the pancreas was apparently normal, and on section showed a round-celled infiltration. Fat necrosis was very limited, the few spots being on the great omentum and in the iliac fossæ. No signs of cholecystitis or gall-stones.

Case 9.—Man, age 50, street salesman. Admitted to St. Bartholomew's, Jan. 26, 1915. On Dec. 18, 1914, patient was thrown off a lorry, injuring his head and abdomen, and was unconscious for about half an hour. The accident was followed by severe pain in the abdomen and back, and morning vomiting. He resumed work in three days, and was fairly well until Jan. 10, 1915, when he first noticed a swelling in the epigastric and umbilical regions. On Jan. 16 he had a large excess of alcohol; on the morning of Jan. 17 he drank a tumbler of cold water, and was immediately seized with a griping pain around the umbilicus which doubled him up. The swelling was also noticed to have increased in size. Micturition was suspended for three days, and followed by hæmaturia. On Jan. 24 he had a second attack of pain. He had been a heavy drinker for ten years. He had dysentery in 1891 and lumbago in 1904. There was no history of jaundice.

On admission to hospital he was a heavily built man; his face was puffy and slightly cyanosed. The abdomen was very soft and distended, and moved well on respiration. A large mass was felt in the abdomen extending from the ensiform cartilage to the umbilicus which was tender and non-fluctuating. The liver dullness was decreased, and free fluid demonstrated in the abdomen. Red blood-cells, 4,640,000; white blood-cells, 32,800. Urine contained sugar. A diagnosis was made of acute hæmorrhagic pancreatitis.

OPERATION, Jan. 26.—Pancreatotomy and drainage. A mid-line incision was made, and patches of fat necrosis were noticed in the great omentum. The lesser sac was explored through the gastrocolic omentum. Two swellings were felt, one over the head of the pancreas and one extending from the left side of the body of the pancreas towards the spleen. They contained much blood-stained serous fluid, which was evacuated. A large red-rubber tube was used to drain the lesser sac.

After the operation the wound continued to discharge blood-stained serous fluid which subsequently became infected with coliform bacilli and streptococci. Several sloughs of pancreatic tissue were extruded at different times. The patient wasted gradually, and died on March 4, 1915.

POST-MORTEM.—Fat necrosis was well marked. The retroperitoneal tissues were suppurating profusely, and in the neighbourhood of the attachment of the mesentery were represented by large putty-like sloughs, apparently originating from the pancreas. The liver was very fatty and the gall-bladder large. No gall-stones were found.

Case 10.—Man, age 42, garden constable. Admitted to St. Bartholomew's on Aug. 6, 1915. On Aug. 2, 1915, when patient was on duty he was seized with an attack of abdominal pain which caused him to fall down and to vomit. The pain, which was most severe in the epigastrium and lumbar regions but also felt in the lower abdomen, and the vomiting, persisted until his admission to hospital. Similar attacks of pain and vomiting were experienced in 1907 and 1909; these lasted about ten days.

The patient weighed 20 stone at the time of his admission to hospital. There was marked jaundice of the conjunctiva. The tongue was furred, and the lips were somewhat cyanotic. Temperature, 100·2°; pulse, 104; respiration, 24. The abdomen was very thickly covered with fat, and moved fairly well on respiration. There was tenderness and rigidity over the epigastrium. No swelling palpable per abdomen. White blood-cells, 20,000. Loewe test, +. Urine: bile, +; acetone, 0; sugar, 0; albumin, +. This case was diagnosed as acute hæmorrhagic pancreatitis.

OPERATION, Aug. 7, 1915.—Pancreatotomy and drainage. A mid-line incision was made above the umbilicus, and the peritoneal cavity was found to contain much blood-stained fluid. There was well-marked fat necrosis in the omentum. The lesser sac was opened through the gastrocolic omentum, and a large collection of brown fluid mingled with sloughs found. There was induration of the head of the pancreas. Gall-stones were present in the gall-bladder. The patient died ten hours after the operation.

POST-MORTEM.—Examination showed acute hæmorrhagic pancreatitis with general peritonitis. Anaerobes and *B. coli* were cultured from the pus.

Case 11.—Man, age 44, engineer. Admitted to St. Bartholomew's, Jan. 6, 1917. Had suffered from abdominal pain since 1913. In January, 1916, he had a sudden attack of pain in the right side of the abdomen, with vomiting. In June, 1916, he had a similar attack. On Jan. 4, 1917, he awoke with severe pain in the right side of the abdomen which caused him to double up and vomit. The pain continued until he was admitted to hospital two days later. The patient, who had previously been given morphia by his doctor, walked into the ward. Temperature, 99°; pulse, 130. He was a well-nourished man and looked healthy. There was no cyanosis. The abdomen was distended and pendulous, and moved on respiration. There was general tenderness and some resistance in the right iliac fossa. Per rectum nothing abnormal could be discovered. Urine was normal. A diagnosis of sub-acute appendicitis was made.

OPERATION, Jan. 8.—Through a gridiron incision the appendix was examined and removed. It was found to be slightly inflamed, but not sufficiently to cause the symptoms. A second incision was made half an inch to the right of the mid-line below the umbilicus. The lesser sac was found to be filled with blood. The pancreas was swollen and soft, and its anterior surface was incised longitudinally and the sac drained. The gall-bladder and ducts were normal. An examination of the fluid removed showed the presence of blood but no organisms. The patient made an uninterrupted recovery, and was discharged from hospital on Feb. 7, 1917. On Jan. 29 the diastase of the urine was 32 units. No sugar was found in the urine at any time, and Loewe's test was not applied.

May, 1923. Patient again seen, suffering from an attack of gout.

Case 12.—Woman, age 57, cook. Admitted on June 16, 1915. Had had indigestion and flatulence for years, and often had epigastric pain and vomiting. On June 15 at 10.30 a.m. she experienced a very severe attack of epigastric pain and vomited several times. The attack continued until her admission to hospital. As a child she had small-pox and typhoid fever. On admission she was seen to be very obese and drowsy; her complexion was cyanotic. The tongue was heavily coated; the abdomen was very full and pendulous and moved slightly on respiration; there was marked tenderness in the lower epigastric region, and some tenderness in both lumbar and umbilicus regions. There was shifting dullness in the flanks, and a fluid thrill was obtained through the lower abdomen. The urine contained no sugar or blood, but a slight amount of diacetic acid and 200 units diastase. Loewe's test was negative. A diagnosis of acute hæmorrhagic pancreatitis was then made.

OPERATION.—On June 18 a laparotomy was performed. Fat necrosis was found in the extraperitoneal fat, and the lesser sac was filled with a blood-stained fluid which was sterile. The pancreas was sloughing and full of blood-clots. The lesser sac was drained with a large red-rubber tube. Recovery was slow, and a tube had to be left in until Aug. 31 owing to continually discharging sloughs from the pancreas. Patient had periodic attacks of abdominal pain, chiefly on the left side; these gradually subsided. The wound was completely healed when the patient was discharged on Sept. 8. At no time during the period she was in hospital had sugar been found in the urine; Loewe's test was negative on June 22, 1915; and on June 24 the diastase of the urine was 100 units.

SUBSEQUENT HISTORY.—Well until February, 1916, when she had a similar attack of pain and vomiting which lasted for a few days. Further attacks were experienced in June, 1916, November, 1916, and March, 1917. In May, 1917, she was re-admitted to hospital for operation for post-operative ventral hernia. On May 19 an examination of the urine showed 0·3 per cent of sugar and 8 units of diastase. On May 25, 1917, she had another attack of acute hæmorrhagic pancreatitis. Laparotomy was performed by Mr. Blakeway, and a little blood-stained serum found in the peritoneal cavity. This was mopped out and the abdomen closed. Culture from the blood gave no growth. On May 31, 1917, the urine contained a trace of sugar and 128 units of diastase. She was discharged cured on June 17.

Case 13.—Man, age 38, cook. Admitted to St. Bartholomew's, July 15, 1912, complaining of severe abdominal pain. On July 15, after drinking an iced lemonade, the patient was seized with very acute abdominal pain referred to the region of the umbilicus, and was brought up to the hospital. He was a very fat man, and on admission was cyanosed and suffering from acute dyspnœa. The abdomen was soft and moved on respiration, and no tumour could be felt. The urine contained a large amount of sugar and 200 units of diastase. Cammidge's test was negative.

Operation was not thought advisable, and the patient was transferred to a medical ward, where he died on July 22, 1912.

POST-MORTEM.—The pancreas was found to be soft and hæmorrhagic. The liver weighed 100 oz. and showed well-marked fatty cirrhosis. The gall-bladder and ducts were normal. There were large areas of fat necrosis in the peritoneum, and the kidneys showed acute nephritis.

Case 14.—Man, age 46. Admitted on April 19, 1911, complaining of severe abdominal pain. Laparotomy was performed immediately and the pancreas drained. The patient died a few hours later.

POST-MORTEM.—Examination showed the body of a very fat male. There was blood-stained fluid in the peritoneal cavity, and extravasation of blood behind the peritoneum. There were patches of fat necrosis amongst the retroperitoneal fat. The pancreas was swollen and completely hæmorrhagic, and is preserved in the museum at St. Bartholomew's. The gall-bladder was shrunken and contained several small calculi. The stomach showed acute dilatation. No organism could be grown from the pancreas or gall-bladder. The heart's blood and peritoneal fluid contained anaerobes.

Case 15.—Lady, age 42. Whilst on holiday was seized with severe epigastric pain and vomiting. She was seen by a local doctor and diagnosed as perforated gastric ulcer, and sent by ambulance to London.

Aug. 4, 1923. On examination, the signs were found to be rather obscured by morphia. The patient was fat, and there were no cyanosis and no jaundice. The abdomen was tender in the lower epigastrium and to the right of the umbilicus, but was fairly soft and moved on respiration. There was no tenderness in the lumbar region. The diagnosis was : ? appendicitis, ? cholecystitis, ? acute pancreatitis.

OPERATION.—The abdomen was opened through the right rectus muscle. The appendix and gall-bladder were normal, but blood-stained fluid was seen between the layers of the great omentum. The lesser sac was then opened below the stomach and blood-stained serous fluid evacuated. The head of the pancreas was swollen and soft. The pancreas was incised in its long axis, and two large drainage tubes were inserted to drain the lesser sac. No fat necrosis was observed at this stage. The fluid from the lesser sac gave a pure growth of streptococci on culture, and the urine showed a diastase content of 100 units. The tubes were removed on Aug. 19.

On Aug. 25 at 2 p.m. the patient had severe epigastric and lumbar pain, accompanied by vomiting, and was given morphia ¼ gr. At 5 p.m. when examined she said she felt very well. There were no nausea and no cyanosis. Temperature, 98·4° ; pulse, 80. The abdomen moved well on respiration, and there was only slight tenderness in the epigastric and lumbar regions.

Aug. 26, 4 a.m. The pain recurred with greater severity, the temperature dropped to 96°, and the pulse rose to 100. She was sweating and collapsed. There was a slight icteric tinge in the conjunctiva, but no cyanosis. The abdomen moved well and was soft, but there was great tenderness above the umbilicus and to the left of the second lumbar vertebra. It was decided to operate.

SECOND OPERATION.—The abdomen was opened through a mid-line incision extending downwards from the xiphisternum. The gall-bladder and ducts were normal. The lesser sac was opened through the anterior two layers of the great omentum, and a little blood-stained fluid and a few small pancreatic sloughs were evacuated. There were a few spots of fat necrosis in the transverse mesocolon. The pancreas was swollen throughout its length, and one soft spot was found about the middle of the body. The organ was incised in its long axis and a large drainage tube inserted. The opening in the great omentum was stitched to the parietal peritoneum, and the remainder of the abdominal wound closed.

For three days following the operation the patient had occasional severe attacks of abdominal pain which lasted two or three minutes each. On Aug. 29 the diastase content of the urine was 100 units, and on Sept. 3 it had fallen to 10 units. On Sept. 8 the tube came out. On Sept. 9 there was severe nausea and some epigastric pain. An anæsthetic was administered and the large tube reinserted into the lesser sac, and a few small pancreatic sloughs were removed. This patient made a good recovery.

Case 16.—(*This is an additional case which is still under observation, and is added as it demonstrates some points referred to.*) Woman, age 46, housewife. Admitted to St. Bartholomew's, Nov. 8, 1923, complaining of abdominal pain. Had suffered from flatulence for years, and for the last two years had been subject to severe

attacks of pain in the right hypochondrium, with vomiting and slight jaundice. These attacks recurred every two or three months and lasted for three to five days. On Nov. 3, 1923, at 4.0 a.m. she was seized with severe pain in the right hypochondrium and epigastrium, having one hour previously vomited bile-stained fluid. The pain persisted intermittently until admission, five days later.

On examination, the patient was seen to be a stout woman with a somewhat dusky complexion, but no cyanosis of lips or cheeks. The conjunctiva was slightly yellow, and the tongue covered with moist white fur. Temperature 100°, pulse 100, respiration 26. The abdomen was very well covered and moved well on palpation. There was slight tenderness in the right hypochondrium, but no tenderness in the right iliac fossa, no rigidity of the right rectus muscle, and no swelling palpable. The knee-jerks were present and there was no œdema of the legs. The urine was dark yellow; S.G. 1020, acid; bile pigments present; no albumin and no sugar; urinary diastase, 50 units. White blood-count, 17,000 per c.mm.

After admission to hospital the patient complained of a pricking pain in the left hypochondrium on deep inspiration. There was no vomiting, and apart from the pain on inspiration she was fairly comfortable. On Nov. 11, some pleuritic friction sounds were heard at the base of the left lung in the mid-axillary line. On the same day the patient passed per anum a faceted pure cholesterol gall-stone one quarter of an inch in diameter. The diagnosis was made of cholelithiasis with gall-stones in the gall-bladder. On Nov. 14, Loewe's test was applied and found to be negative. Urinary diastase, 100 units. W.B.C. 20,000. An additional diagnosis of subacute pancreatis was now made and immediate operation recommended. During the period of observation (Nov. 8 to Nov. 16) the temperature varied from 99·5° to 100·5°, and the pulse from 98 to 105. The bowels were opened, there was no vomiting, and the urine was free from bile pigment after the second day.

Operation, Nov. 16, 1923.—The abdomen was opened by a right supra-umbilical rectus incision. The peritoneal cavity was found to contain some blood-stained fluid, and numerous areas of fat necrosis were observed on the great omentum. The gall-bladder was enlarged and contained numerous stones. This was removed, and the cystic duct was ligatured close to its junction with the common bile-duct; the latter duct contained no stones. The body and tail of the pancreas were found to be enlarged and indurated and projecting above a ptosed stomach. The gastro-hepatic omentum was divided and the body of the pancreas incised in its long axis, when a mass of black slough was removed. Some hæmorrhage from this area was controlled with gauze plugging, and a large drainage tube was inserted down to the space in the pancreas. The cut edges of the opening in the lesser omentum were sutured to the parietal peritoneum, and the wound closed in layers, catgut being used entirely for the buried sutures.

After the operation the temperature fell gradually to normal on Nov. 23. Pulse, 88 to 100. The plugging was removed on Nov. 19, and the wound dressed four-hourly for the first three days. There was free discharge of blood-stained purulent material and greyish sloughs from the pancreas. By Nov. 21 the urinary diastase fell to 50 units, but was 100 again on Nov. 25 and Nov. 28. On Nov. 26, the W.B.C. had fallen to 10,000. The free discharge of thick purulent material and greyish sloughs still continuing, the wound is irrigated twice daily.

Dec. 1. Progress continued, but drainage tube still in

FRACTURE OF THE FEMUR: A CLINICAL STUDY.

By R. HAMILTON RUSSELL, Melbourne, Australia.

The man who invented the term 'simple fracture' has been called an unconscious humorist, and the quip derives some justification from the frequency with which closed fractures are found to present so much difficulty in their management as to require operative fixation of the fragments. All are agreed that the opening up of a simple fracture is a measure to be deplored; but all are not agreed as to the exact reasons which render such a serious step imperative. We hold that there is only one circumstance that can justify such a surgical procedure; that is, mechanical impediment to the reposition of the fragments. To put it concisely, the purpose of operation must only be to enable fragments to be brought into position; and operation is not justified when its purpose is merely to keep them there. During the last ten years the method I shall describe, and its guiding principles, have been very thoroughly tested at the Alfred Hospital, Melbourne, and during the last two years at the Children's Hospital also.

I purpose to examine first the problems presented by the simplest kind of simple fracture, in which there is no obstacle to the restoration of the fragments to their normal position, no incarceration of the broken ends in soft tissues, no interposition of muscle. In such a case (and of such are the large majority) the fragments can be easily brought into good position and maintained there; and from its careful study principles will emerge that should be found of value in the treatment of all varieties of fracture involving the long bones.

Let us suppose a patient with fracture of the middle of the femoral shaft just admitted to hospital.

The Thigh is Shortened. Why?—The shortening is caused by the tonic contraction of certain long muscles that are attached above to the pelvic bone, and traverse the entire length of the thigh to be inserted into the tibia and fibula (*Fig.* 283). Of these there are two opposing sets, consisting (in the main) of the hamstrings and the rectus femoris. Hence the semidiagrammatic representation of these muscles alone in the figure; for the numerous muscles that are attached to the femur itself play little if any part in the production of shortening, and for the sake of clearness are omitted from the diagram.

Muscular *tone* (which must always be carefully distinguished in our minds from muscular *action*) is a physiological property of living muscle, which for practical purposes causes the muscles to behave like rubber bands slightly stretched. Their correct length is maintained by the length of the femur, and as soon as the femur is broken they shorten and produce over-riding of the fragments. Here the analogy ends, for rubber once released from its tension will have no further power of contraction, whereas the tonic shortening of the

muscles will be progressive. Hence the excessive shortening, amounting to three or four inches, that almost invariably complicates an ununited fracture of the femur.

Our first aim, then, will be to pull out these muscles to their correct length; and when we have accomplished this we may be sure that every other structure in the thigh will be in its correct position, including the fragments. This does not mean 'exact anatomical reposition', which is neither necessary nor even, in my opinion, always desirable. I shall shortly allude to this later.

What must we Pull upon?—Clearly the tibia and fibula, seeing that the muscles are attached to them. We are going to use strapping and bandages for the extension, and we shall accordingly not carry them above the knee, for reasons that are obvious. I think that the practice, which seems universal, of carrying the strapping up the thigh indicates some confusion in our mental picture of the object to be attained. Anxiety as regards the ligaments of the knee seems also to be felt; but this is quite needless, for the ligaments

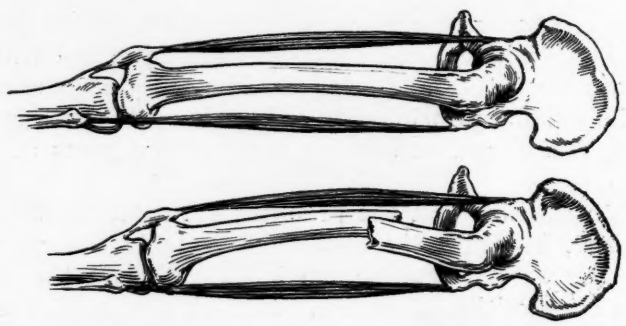


FIG. 283.—Illustrating the action of the long muscles in producing shortening.

of the knee, being attached to a fragment, cannot be subjected to stretching. The whole of the extending force will fall on the muscles, none at all on the ligaments; to convince ourselves of this, we only have to reflect that if the muscles were severed at the seat of fracture the limb would drop off.

How must we Pull upon the Tibia and Fibula?—If we merely attach a weight to the leg to pull out the thigh muscles, it is obvious that the leg and thigh will have to be in a straight line, or the thigh muscles cannot be extended. But this will never do; for one among several reasons, it would be intolerably uncomfortable; and perfect comfort, as we shall see, is the first essential requirement in any appliance for the treatment of a fracture. We must have the knee slightly bent; but the bending of the knee is incompatible with the necessary pull on the thigh muscles that are attached to the tibia and fibula.

In a difficulty of this kind I always advise my students to do this. First take hold of the fractured limb with both hands and bring it into perfect position. Holding it thus, study carefully the position and *direction* of the forces you are applying. Then see if you can devise some plan of incorporating similar forces in an apparatus of some kind. In the case of the fractured femur, how does the surgeon manipulate it in order to draw out the thigh

muscles? He will do it in the following way (*Fig.* 284). Standing by the side of the bed he passes the left hand under the knee; the right hand grasps the leg above the ankle. Now he gradually exerts a little power, the right hand pulling horizontally towards the foot of the bed, the left hand up towards the ceiling mostly, but with a slight inclination footwards also. The direction of the forces being exerted by the surgeon's hands are indicated by the arrows in the picture. The limb will not come out to its proper length all at once, but the patient will feel more comfortable, and will instinctively know that his limb is being skilfully and properly handled.

The surgeon now reasons thus: I am sure that this is the right way to get the thigh out to its proper length if only the thigh muscles were quiescent; but they are not, owing to the patient's apprehension and fever. Were I able to stand here doing this for a few hours or until he sleeps, then there

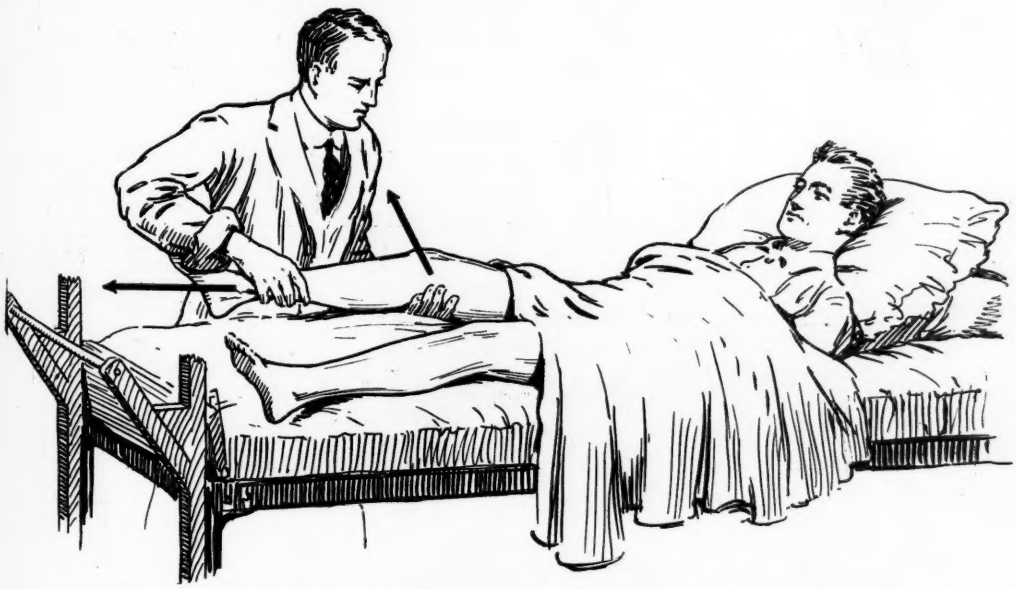


FIG. 284.—Manipulation to draw out the thigh muscles, the direction of the forces exerted being indicated by arrows.

would be no difficulty; but obviously that is not possible. I must then devise some means of doing what I am now doing; something that will not tire, that will make the limb absolutely comfortable, and in that way favour the return of mental quietude.

The Apparatus.—The arrangement shown in *Fig.* 285 was evolved in the way just described—a sling beneath the knee corresponding to the surgeon's left hand, and horizontal traction on the leg corresponding to the surgeon's right hand. The arrangement provides that the pull on the leg shall be nominally double the upward lift at the knee, although actually somewhat modified by friction between pulleys and cord. The special apparatus required is as follows:—

1. An ordinary overhead head-to-foot bar that can be shifted laterally as required. This can be fitted to the ordinary four-posted frame; but a

convenient way is to use merely two uprights at head and foot respectively, securely lashed to the bedstead.

2. An arrangement to which may be attached a couple of pulleys beyond the foot of the bed. These pulleys should be in a horizontal line with the foot of the patient when the leg is lying horizontally on a pillow with the heel just clear of the bed. A convenient wooden or iron bracket can easily be made by the carpenter or the splint-maker.

3. Four block-pulleys and suitable flexible cord.

Application of the Apparatus.—Usually an anæsthetic is not required; children have been known to sleep through the whole procedure.

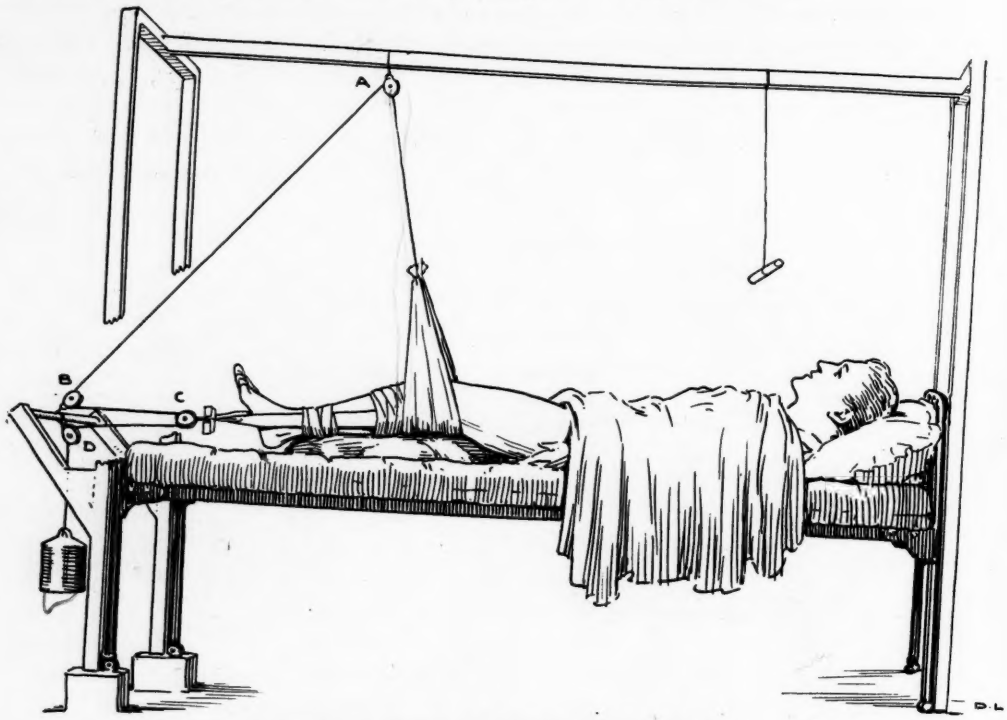


FIG. 285.—Showing the application of the sling.

1. The leg having been prepared in the ordinary way is fitted with a spreader or stirrup close to the sole of the foot by a method similar to that used in 'Buck's extension', but with two important differences: (*a*) The strapping is not carried above the knee; (*b*) The spreader is provided with a pulley. A pattern of spreader we have found convenient is shown in *Fig.* 286, but its essential feature is that it must be long enough (5 in.) to deflect the strapping sufficiently to protect the malleoli from pressure. A light bandage over all from the roots of the toes to the knee, and the leg is ready.

2. The placing of the pulleys (*see Figs.* 285, 287). First, pulley **A** is tied to the overhead bar in such a position that a vertical dropped from it shall meet the leg well below the knee. Pulleys **B** and **D** are to be attached separately to the bar beyond the foot of the bed; pulley **C** is that attached to the spreader.

3. The knee-sling is now passed beneath the knee, which all this time has been lying comfortably on a pillow. The sling should be broad and soft; a soft rough towel suitably folded answers well. The ends of the sling are now securely tied together with the cord, which is then passed through the pulleys in the following order: (*a*) Up to pulley **A**; (*b*) To pulley **B** beyond the bed; (*c*) To pulley **C** on the spreader; (*d*) To pulley **D** (companion to **B**).

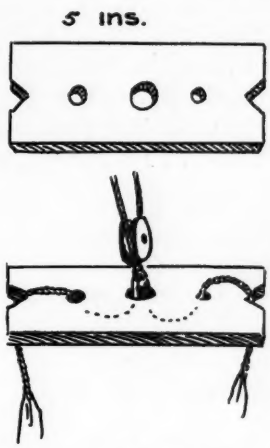


FIG. 286.—The spreader.

4. The surgeon now stands at the foot of the bed and slowly tightens up everything, and then the weight is attached. He next takes a soft pillow and adjusts it comfortably beneath the thigh to prevent gravitational sagging at the seat of fracture. Care must be taken that the pillow is really soft; a common fault is to have too hard and tightly-stuffed a pillow for this purpose. Next he looks to the heel; it must not be touching the bed, and he arranges another soft pillow beneath the leg and tendo Achillis to prevent it from doing so. And now the patient will be absolutely comfortable, and rest of both mind and body (including thigh muscles) will come to him. Finally, careful measurements are taken from the lower extremity of the anterior superior iliac spine to the upper margin of the patella on either side. Quite

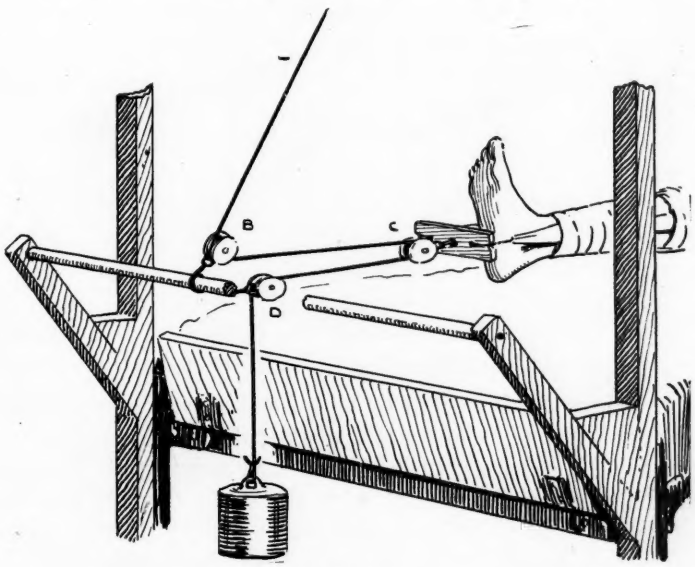


FIG. 287.—Showing the arrangement of the pulleys.

possibly, especially if the manipulations have been leisurely and quiet, the length will already be nearly normal.

I notice that the first question usually asked is, "What prevents the occurrence of eversion?" The knee-sling prevents it. Upward lifting of the

bent knee is the natural way of inverting the limb, when we wish to correct eversion; instinctively we first bend the knee and then lift it upwards. The practical fact is that eversion gives no trouble.

The usual weight required for an adult is 8 lb.; for infants and older children ½ lb. to 4 lb. These weights, it will be noted, are doubled by the pulley arrangement nominally; but in practice it would seem that there is considerable modification of the pull one way and another, and considerable latitude within the range of efficiency. The truth seems to be that really a very moderate pull is adequate, provided that it is fairly constant and comfortable. At the end of the third week we always seek to reduce the weight.

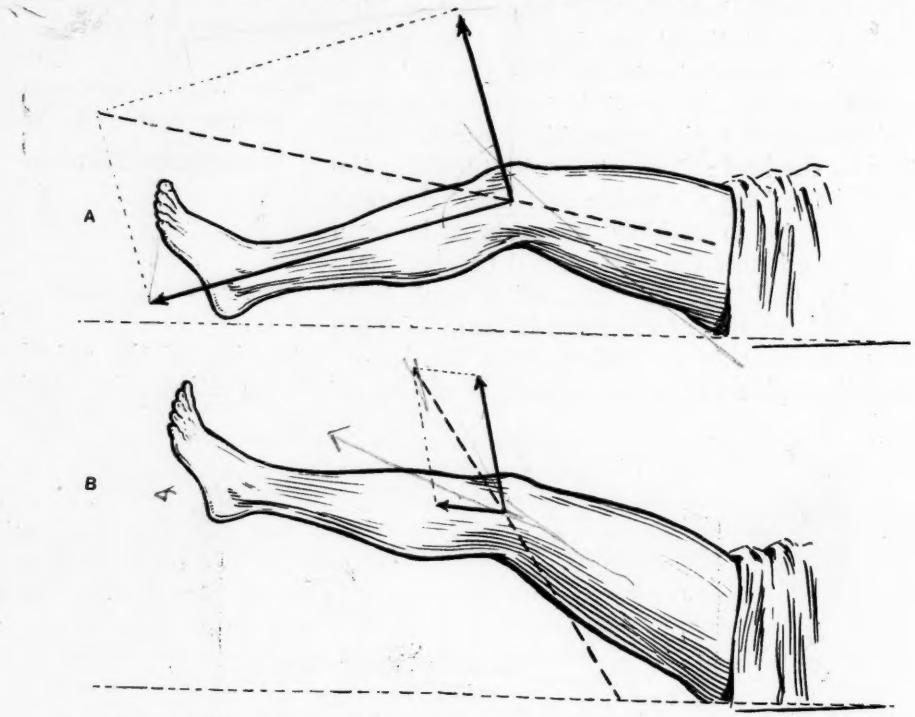


FIG. 288.—Mode of action of the two forces employed. A, Correct position; B, Faulty position.

The house surgeon's duty will be to take the measurements at least every morning and evening, and to inspect and adjust the pillows beneath the thigh and the leg so that there may be no backward sagging at the seat of fracture and the heel shall not be in contact with the bed. It is very little to require of him; but while it is very little and very easy, yet it is absolutely indispensable and must be faithfully given. The apparatus is far from being 'fool-proof', and cannot and will not look after itself.

Survey of What has been Done.—The thigh muscles are being extended by a combination of two forces. We have seen why it is impossible to attain this object by a single force acting in a straight line. The accompanying diagram (*Fig* 288, **A**) will make evident the mode of action of the two forces employed. By constructing a parallelogram of forces on them, it is seen that the resultant

will lie in the line of the thigh. Again, it will be noted that we have apparently taken no measures to secure and preserve good alinement; but bad alinement need never be seen in fractures treated in this way. Our teaching on this matter is very simple, and is somewhat at variance with traditional views; it may be stated thus:—

1. *In a limb previously normal that is rendered perfectly comfortable in a natural position, muscular action is never the cause of displacement of fragments.*

2. The causes of malposition of fragments are three in number, viz.: (*a*) Unnatural position and discomfort; (*b*) Action of gravity; (*c*) Splints. Some explanation is demanded, and we will examine these causes of trouble *seriatim*.

a. Unnatural Position and Discomfort.—I believe that the most universal and the most unfortunate error that has hampered the treatment of fractures is the belief (under which I in common with others laboured for many years) that the limb must be placed in a certain position to meet the supposed requirements of a short proximal fragment that is being uncontrollably displaced by a certain muscle. I would instance the case of the iliopsoas muscle in fracture just below the lesser trochanter; and an equally good example taken from the upper extremity will be the visible displacement of one or other fragment of a broken humerus by the deltoid muscle. It would at first sight appear almost incontestably right in principle that the limb should be brought into alinement with the proximal fragment that is being pulled out of place in this way. I submit, however, that this is not so, for the following reason. The visible displacement, obviously caused by muscular action, is only a transient phenomenon, and will disappear as soon as the limb is put into a comfortable position and the surgeon's back is turned. So that when, with considerable pains and ingenuity, we have fixed the limb in an unnatural and uncomfortable position in deference to the proximal fragment, we shall find (or not find) that the proximal fragment ten minutes later will have changed its position altogether, that it and its muscles have assumed the position to which they are accustomed, and that the position we have assigned to the limb is altogether wrong. We ought to have disregarded the proximal fragment altogether, and placed the limb in a position that we know to be natural and comfortable, with the assurance that the position which is natural and comfortable for the entire limb will be equally so for the proximal fragment in common with the rest, and that such position will be that which it will assume.

Muscles are the creatures of habit and the slaves of custom. In a broken limb, every muscle and muscle fibre will co-operate in the endeavour to preserve the position to which it has always been habituated, and the last thing a muscle will do will be to abuse its liberty by displacing a fragment into an unnatural and unaccustomed position. Hence the remarkable circumstance that with our methods faulty alinement (other than that induced by gravity) is practically never seen, although great liberty is permitted.

It follows, moreover, that whether the fracture is in the upper, middle, or lower third, the treatment is exactly the same; the position of the limb and the mode of extension is equally appropriate in all three cases.

The foregoing paragraph had scarcely been written when the following

curious illustration of its truth occurred. I saw in consultation a very stout woman who I was told had a supracondylar fracture of the femur in very good position. I gave a cursory glance at the singularly misleading skiagram, and was well satisfied. It was not until she had been under treatment four or five weeks that I was informed to my amazement that a mistake had been made and that the fracture was not a supracondylar fracture but a subtrochanteric one. There were other circumstances, which need not be detailed, that conspired to bring about this almost incredible incident; but the essential point is that the treatment we believed we were applying to the supracondylar fracture answered equally well for the subtrochanteric, and the result could not have been bettered.

b. The Action of Gravity.—This is the sole inescapable cause of angulation in the case of the femur, and is met and counteracted with the utmost ease, as has been already described. It is a great advantage of our simple methods that the seat of fracture is always exposed to inspection and easy handling.

c. Splints.—The means of avoiding this source of difficulty is obvious. The Thomas splint, invaluable for many purposes, we never employ in the treatment of fracture of the femur, whether simple or compound.

To recapitulate: In fracture of the femur, given a method of pulling out the thigh muscles to their normal length by an appliance that is perfectly comfortable, nothing will then remain to be done except to counteract the effect of gravity at the seat of fracture.

This sounds almost too simple; it is, however, absolutely correct in principle, and it works well in practice when carried out with care. Experience has shown, however, that the practice presents difficulties and pitfalls that have to be known and recognized. What at first sight appear to be small details in the management of the cord and pulleys turn out to possess unexpected possibilities. I am always interested when asked by a house surgeon to see a case that he thinks is not satisfactory; it often ends in a valuable addition to the knowledge of us both. I will endeavour to give the substance of some of our bedside discussions with conciseness.

Examples.—

Example 1 (*Fig.* 288, **B**).—Patient has been in several days, but the length will not come right. The reason is at once obvious; the foot is too high; and this I have found to be the most frequent of all errors for some reason. The heel should be almost, but not quite, touching the bed, whereas here it is several inches away from the mattress. We must lower the extension pulleys to the proper level, so that the leg becomes horizontal (*Fig.* 288, **A**); and we must understand clearly the significance of this mistake and what had happened as a result of it. In the first place, a great part of the weight was employed in counteracting the weight of the limb, so that there was no power left for the purpose of extension of the thigh muscles; and they were not being extended at all, or very little. It is well, also, to reflect on what had happened to our parallelogram of forces, owing to the horizontal force having been so diminished; at the best the resultant (if there was a resultant) would have been directed almost vertically upwards, and not in the line of the thigh at all. Now that the leg has been brought down to the horizontal,

we shall find that the length will be distinctly improved at once. The patient will be more comfortable; and this is not merely a humane consideration but a physiological one, and of fundamental importance in the treatment of a fracture.

Example 2.—The same difficulty as to length. Here, although the position of the leg and thigh is right, the fault lies in the direction of the upward pull on the knee. The pulley **A** is wrongly placed, being too far up towards the bedstead-head, with the result that the upward pull is rather against the horizontal pull instead of co-operating with it. All we have to do will be to shift the position of pulley **A** footwards so as to change the direction of the lifting cord. The pull on the thigh can often be conveniently increased or diminished within narrow limits by merely altering the position of pulley **A** headwards or footwards as the case may be.

Example 3.—The same difficulty as to length. The patient is a child, and will provide a study of great interest—the production of shortening by too heavy a weight. It is most likely to be seen in children, for reasons that are obvious; at the same time its teaching applies equally in the case of adults. In examination we find that the position of the leg and foot is horizontal; that the position of pulley **A** is right, and that our parallelogram of forces is consequently as it should be. But we notice that the child's pelvis is much pulled down on the injured side, so that it is lying very obliquely. This explains the shortening, and we now find that, through error, a weight of 5 lb. is being used, which is a great deal too much for a child three or four years old. What has happened is that, by the pulling down of the pelvis, the limb has been brought into a position of extreme abduction. I do not think it is always realized that, while some abduction of the thigh in the treatment of fracture is favourably regarded, the amount permitted should be carefully limited, and should not be more than is present when a man stands with his heels three or four inches apart.

The means by which abduction of the limb causes over-riding of fragments and shortening must be explained at some length; the simplest, most practical, and shortest way will be to study with the aid of the tape measure certain phenomena produced by abduction of the normal limb.

In the accompanying diagram (*Fig.* 289, **A**) of the pelvic bone and the femur, four things are to be noted: namely, the three points indicating the positions of the head of the femur, the tip of the great trochanter, and the anterior superior iliac spine; and the adductor magnus with its lowermost attachment to the adductor tubercle on the inner condyle. At first sight it would appear that the presence of the adductor magnus would render abduction of the limb impossible; it is only rendered possible by the presence of the neck of the femur. Were the anatomy such that the shaft of the femur passed directly up to the acetabulum, abduction would be impossible. As it is, the femoral neck becomes the radius of a circle having the femoral head for a centre, while the tip of the trochanter lies on the periphery. When the limb is abducted (*Fig.* 289, **B**), the trochanter passes upward through the arc of a circle, thus approaching the anterior superior spine, and the extent to which the level of the trochanter will have been raised will be made evident by the shortening recorded by the tape measure. This is the mechanism of

abduction in the normal limb; but the matter becomes altogether different when there is a fracture of the shaft of the femur. In the presence of fracture it is not necessary that the neck of the femur should play any part at all. The trochanter need not move upwards, for the requirements of the adductor magnus will be quite as well, and more easily, met by the passage upward of the lower fragment only, by over-riding of the fragments in fact; and this is what will almost inevitably occur (*Fig.* 289, C).

Now, armed with knowledge of the nature and cause of the difficulty, what shall we do? We take off a couple of pounds from the weight; we can also reduce the abduction by shifting the leg with its pulleys a little towards the mid-line of the bed. Still the pelvis remains very oblique. The natural suggestion is offered that a well-padded perineal band should be applied on the injured side and tied firmly to the bed-head; by this means counter-extension and pulling up of that side of the pelvis will be secured. I, on the other

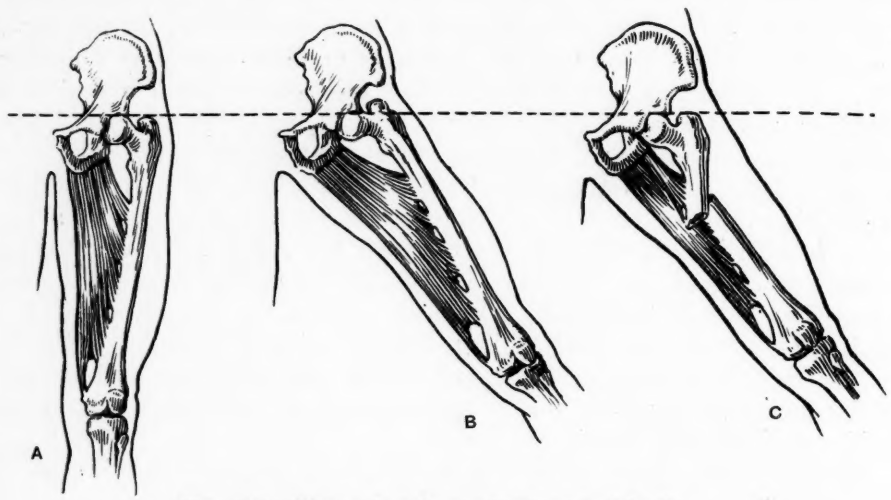


FIG. 289.—Illustrating the mechanism of abduction.

hand, would rather put an extension on the sound side and pull that down. Finally, it is decided to wait and see, and the intelligent Sister would do what she could now and again to straighten out the little patient. The next day it was quite evident that all was going well; the length was quite right, and, in short, no further measures were needed and the case gave no further trouble.

Example 4.—I have left this case to the last, because it illustrates the greatest and most momentous of all the problems presented by simple fracture. The length will not come right although the case has been in two or three days. On examination there is no fault to be found with the apparatus, and yet the limb remains one or two inches short. We know that the means that have been adopted are to be trusted to bring the limb to the normal length, provided always that there is no mechanical impediment at the seat of fracture. When there is interposition of muscle, or the fragment has been thrust through muscle, periosteum, or other fibrous tissue, and incarcerated so that the fragments cannot come into good position, the measurement will be persistently

short. Hence we are acutely on the alert, for now is the time to rescue the patient from one of the greatest disasters that can befall. We suspect that there is interposition of muscle between the fragments, and that, unless we interfere promptly, the man will be pronounced in a few weeks to be suffering from an ununited fracture of the femur with three or four inches of shortening. There are two further observations we can make. First, on feeling the contour of the limb, we discover, at some spot in the neighbourhood of the fracture, a 'lumpiness' that is not normal, due to the projection outwards of one of the fractured ends. Again, take the tape measure and measure carefully the length from the anterior superior spine to the top of the patella; and while the measure is held thus, let the house surgeon very gradually increase the traction on the limb; the thigh is seen to lengthen out almost to normal. Now the house surgeon slowly releases the weight again, and the limb recoils like a piece of stretched rubber. This peculiar elastic recoil is quite characteristic. There is no doubt as to the diagnosis, nor is there any as to the correct treatment, which will be operative. The seat of fracture will be freely exposed, and the surgeon must be prepared for difficulties, mostly difficulties of 'seeing'. A tourniquet will be helpful, and usually quite worth while. The interposed tissues should be cut across rather than pushed aside; and the surgeon, being satisfied that the fragments have been released, will close the wound, and the case will thenceforth be treated as a simple fracture.

Results.—It has become very clear to us that the general behaviour of fractures treated in this way contrasts favourably with that usually seen where other more 'restrictive' methods are employed. I can only explain it by suggesting that all the tissues of the limb, notably the muscles and bones, preserve their nutrition better when merely laid upon a pillow with considerable freedom of movement, than when subjected to the compression associated with splints and bandages. I think that union takes place more rapidly than of old, and the patient is certainly up on crutches earlier and the crutches are discarded sooner. Among other things I have been struck with the remarkable rapidity with which consolidation takes place, so that the fracture will pass from almost no union to firm union in the course of a week.

A frequent experience is as follows: At the end of the third week there will be only just perceptible evidence that the fragments are beginning to join, but free mobility is of course still present; a week later consolidation will be complete, so that all the apparatus can be removed. Needless to say, the capacity for rapid repair of fractures varies somewhat, but it is rare for complete consolidation to be delayed beyond the fifth or sixth week. In children firm union is constantly present before the end of the fourth week, but I make it a rule to wait until the fourth week is completed before releasing the limb. Our plan is, after the apparatus has been removed, to keep the patient in bed for a week; during this time he moves about freely in bed, and may occasionally sit on the side of his bed and dangle his legs. If union should be imperfect, there will be a loosening and an access of tenderness at the seat of fracture; but I have rarely known this to occur in a fracture treated in this way. At the expiration of the week of probation he is allowed up on crutches, and is encouraged to put a little weight on the limb;

very soon the crutches are discarded for a couple of sticks. No plaster bandage or other support is applied, nor is massage employed. I am strongly of opinion that the application of a plaster support to the limb when the patient is first allowed to walk is a source of weakening, and is favourable to bending—an observation that was made years ago, I think very acutely, by one of my colleagues at the Children's Hospital.

Newly-born and very young infants are treated in this way at the Children's Hospital. When two years ago I first saw a tiny infant lying in a cot rigged up with Lilliputian pulleys and string, and was amused thereat, the sister was so emphatic and serious in her approval that all doubt was at once banished, and no other method has since been even thought of. The nurses find that such patients give no trouble, and are tended and washed with the utmost ease and comfort.

Again I would insist that there is only one kind of faulty alinement or angulation likely to threaten trouble in fractures treated in this way, and that is the gravitational backward sagging at the seat of fracture, which is due to the lack of the most ordinary care. Outward curvature is practically never seen.

One more word as to the significance of comfort. Comfort is the first essential in the treatment of a fracture. No apparatus that is not perfectly comfortable can be a good apparatus, for the muscles will never be at rest, but will always be striving to achieve a position of greater comfort. Moreover, there is, I am convinced, a direct relationship between comfort and rapid union, and an equally direct relationship between discomfort and delayed union, feeble union, and non-union. Explain this how we may, I have no doubt whatever about the clinical fact as a matter of bedside observation. Therefore let us never be content with any means, no matter how ingenious, and complicated, and satisfying to our theoretical preconceptions, that is not perfectly comfortable.

THE RELATIVE FREQUENCY OF THE VARIOUS POSITIONS OF THE VERMIFORM APPENDIX:

AS ASCERTAINED BY AN ANALYSIS OF 3000 CASES: WITH AN ACCOUNT OF ITS DEVELOPMENT.

By REGINALD J. GLADSTONE and CECIL P. G. WAKELEY, London.

A great deal has been written concerning the position of the cæcum and appendix; but notwithstanding the excellent work which has already been done, there is a general feeling that the individual experience of many surgeons and anatomists does not conform with the statements that have been published and accepted with regard to the relative frequency of the different positions assumed by these organs. It was on this account that in 1914 we commenced making careful observations upon the position of the appendix as seen in the operating theatre, post-mortem and dissecting rooms, and by the middle of this year the total number of cases in which the position of the appendix had been recorded amounted to 3000. The cases will naturally include, in addition to those in which the normal position was unaffected by inflammatory adhesions or traction bands, the usual cases which are likely to be met with in surgical practice—for example, the acute and chronic cases of appendicitis. We have, however, thought it unnecessary to complicate the classification by introducing accidental factors into the statistics. The position of an abscess is most likely to be determined by the original position of the appendix and the surrounding folds of peritoneum, and the influence of inflammation in altering the normal position of the appendix is not of sufficient importance to interfere with the general value of the statistics which we have collected. One of the objects we have had in view has been to afford an explanation of the various typical positions in which the cæcum and appendix are found, and we have thus examined a series of human embryos and fœtuses up to the time of birth and included a description of the changes which they undergo during this period.

As the position of an inflamed or gangrenous appendix and its relationship to adjoining parts frequently determine the site of an abscess, it is important that the surgeon should have some knowledge of the relative frequency of the various situations in which the appendix may be found and its relationship to the surrounding pouches and folds of peritoneum.

A good deal of misconception arises out of the use of certain terms in regard to the folds of peritoneum and fossæ around the cæcum and appendix. As it is of the greatest importance that these names should denote a definite condition, we have thought it necessary at the outset to define clearly what we understand by the terms employed in this article. The terms which we propose to use are given in the following table, and details with regard to the exact position of the appendix and the peritoneal folds and fossæ follow.

TABLE SHOWING POSITIONS OF THE APPENDIX, WITH THEIR RELATIVE FREQUENCY.

POSITIONS OF THE APPENDIX	NO. OF CASES	PER CENT
1. Anterior or pre-ileal	27	0·9
2. 'Splenic' or post-ileal	15	0·5
3. 'Pelvic'; on psoas muscle, near or hanging over the brim of the pelvis	825	27·5
4. Sub-cæcal, beneath the 'caput cæci'	56	1·86
5. Post-cæcal and retrocolic	2076	69·2
6. Ectopic	1	0·035
	3000	100·0

1. **The Anterior or Pre-ileal Position** (*Fig.* 290) is uncommon (0·9 per cent). The appendix is directed upwards and forwards towards the abdominal wall, and also medially in front of the terminal part of the ileum. The meso-appendix is unusually long; its free edge is directed upward and the appendicular border is to the right. The original posterior surface is thus turned forward and the anterior backward, so as to cover over the ileocæcal fossa, which may become obliterated as is shown in the drawing.

Should the organ become inflamed it may form adhesions to adjacent coils of small intestine, and an abscess may form between these coils and the appendix. Generally, however, the great omentum is early on the scene, and often completely surrounds the appendix; in this case the inflamed mass may be felt on abdominal palpation.

In the case represented in *Fig.* 290, two lobulated folds of peritoneum containing fat extended upward one on each side of the appendix from root to tip. There was a well-marked genitomesenteric fold extending from the ileum, where it was attached to the left side of the meso-appendix, down to the margins of the aperture of a hernial sac. The sac was empty, about one inch in length, and its opening lay to the inner side of the origin of the deep epigastric artery, which vessel crossed above the neck from the outer to the inner side, and thus closely encircled the orifice of the sac in about two-thirds of its circumference. The hernial sac, although 'internal', was oblique in position, and it did not appear ever to have contained any viscus. A lobulated mass of fat which occupied the lower part of the inguinal canal was adherent to its external surface and must have exerted traction on the peritoneum, drawing it downward into the canal. The 'caput cæci' descended to within one inch of the hernial orifice, and the outer and lower border of the cæcum was bound down to the outer end of Poupart's ligament and the iliac crest by four or five short parietocæcal folds of peritoneum. The posterior surface of the cæcum was directly adherent to the floor of the iliac fossa. The terminal part of the ileum was directed downward at its junction with the cæcum so as to form an acute angle with the ascending colon. At the point of attachment of the genitomesenteric fold there was a sharp bend with the convexity directed upward, and the ileum proximal to this was considerably dilated, and contained solid fæcal matter. The specimen, therefore,

forms a marked contrast to the case represented in *Fig.* 292, in which the ileum was kinked in a downward direction, and the tip of the appendix was also directed downward. In both cases the ileum was held above and below by strong peritoneal bands; in *Fig.* 291 it appears that the upper band had obtained the mastery over the lower band; while in *Fig.* 292 it would appear that the lower of the two contending forces was the stronger. Both cases were found in old dissecting-room subjects, and the constriction of the ileum appeared to have been of long standing.

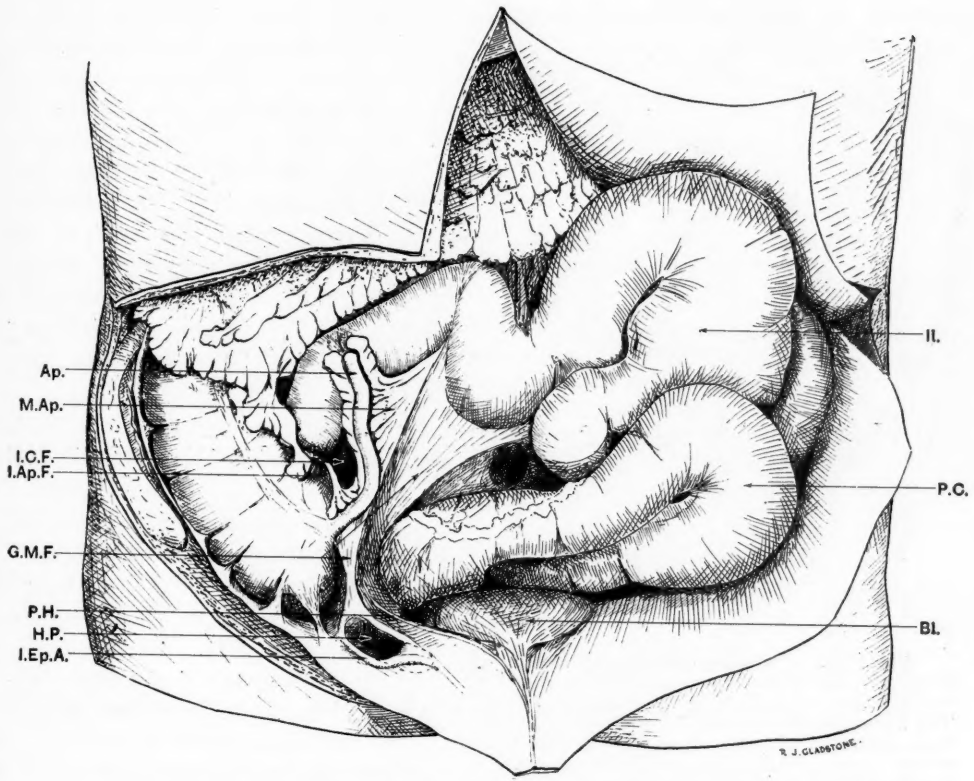


FIG. 290.—Pre-ileal position of appendix. Observed in an aged male subject, in whom there was a well-developed genitomesenteric fold, connected below with the orifice of a hernial sac and the right 'plica hypogastrica'; above, it was attached to the root of the appendix and its mesentery, and also to the terminal part of the ileum, which was kinked in an upward direction opposite the attachment of the fold. The part of the ileum proximal to the kink was distended with gas and hardened fæces.

Ap., Appendix cæci. *Bl.*, Bladder. *G.M.F.*, Genitomesenteric fold. *H.P.*, Orifice of hernial pouch. *I.Ap.F.*, Ileocæcal fold. *I.C.F.*, Ileocæcal fossa. *I.Ep.A.*, Fold raised by inferior epigastric artery. *Il.*, Distended ileum. *M.Ap.*, Meso-appendix. *P.C.*, Pelvic colon. *P.H.*, Plica hypogastrica.

2. **The 'Splenic' or Post-ileal Position** is still more uncommon; only 15 (0·5 per cent) were observed in our 3000 cases. The appendix passes upward and to the left beneath the mesentery, or it may be curled up in the ileocæcal fossa (*Fig.* 291) under cover of the terminal part of the ileum and the ileocæcal or 'bloodless' fold of Treves. In the specimen figured this fold was loaded with fat, and, like the ileum, it has been drawn upward in order

completely to expose the appendix. The appendix and its mesentery were adherent to a well-marked genitomesenteric fold, to the right of which was a parietocæcal band which passed upwards behind the 'caput cæci' to the root of the appendix. A narrow and deep recess lay between the genitomesenteric and parietocæcal folds, which we regard as a subdivision of the post-cæcal fossa. In the 'splenic' type of the post-ileal position of the appendix, where the tip is directed upwards and to the left beneath the mesentery, there is a likelihood, should inflammation occur, of the appendix becoming adherent to the mesentery, and setting up mesenteric thrombosis. Should the appendix be retroperitoneal it may lie behind or even within the root of the mesentery (intramesenteric position). In such cases, if inflammation occurs, mesenteric thrombosis is almost inevitable.

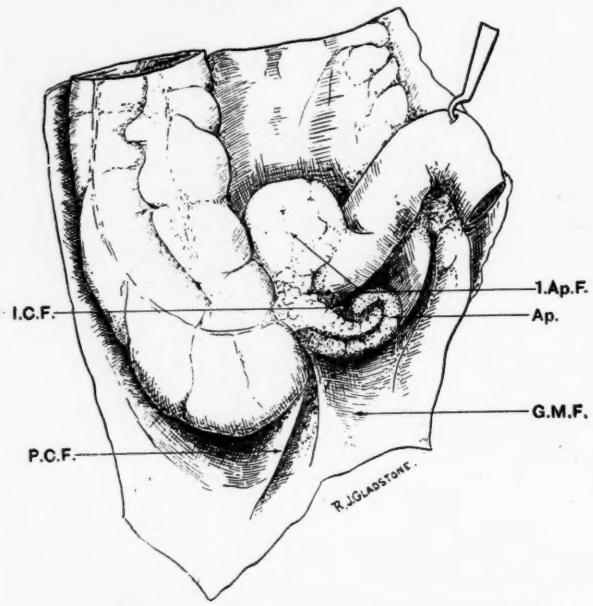


FIG. 291.—Post-ileal position of appendix. From an old dissecting-room subject, showing the tip of the appendix lying in the ileocæcal fossa. The ileo-appendicular fold is loaded with fat, and with the terminal part of the ileum has been drawn upward, so as to expose the appendix. A subcæcal fossa is divided by a parietocæcal fold into an outer part lodging the cæcum, and an inner which is bounded medially by a genitomesenteric fold.

Ap., Appendix. *G.M.F.*, Genitomesenteric fold. *I.Ap.F.*, Ileocæcal fold. *I.C.F.*, Ileocæcal fossa. *P.C.F.*, Parietocæcal fold.

3. The 'Pelvic' or Descending Position is quite common, 27·5 per cent in our series. In this type the appendix passes downwards on the psoas muscle and may overhang the brim of the pelvis. The meso-appendix is usually long, and there is often a genitomesenteric fold, lying medial to the appendix and its mesentery. This is usually attached to the ileum or the under surface of the mesentery of the small intestine about three inches from the ileocæcal valve (*Fig.* 292). In this specimen there was a marked constriction of the ileum and a kink in the downward direction, so that the terminal part of the ileum ascended to the ileocæcal valve. The mesenteric attachment of the meso-appendix had in consequence been drawn downwards with the terminal part of the ileum, and the descending position of the appendix had thus been rendered possible. In *Fig.* 290, showing the ascending or pre-ileal type, the reverse condition is present, the meso-appendix is drawn upward with the ileum, which in this case descends from an upwardly-directed kink to the ileocæcal valve. In the example shown in *Fig.* 292 of the descending type it will be seen that there is great distension of the ileum on the proximal side of the constriction, and also that the testes are incompletely descended. The penis and scrotum are small, and the pubic hair scanty. The lower end of the genitomesenteric fold is subdivided into an ill-defined ridge

continuous with the fold raised by the obliterated hypogastric artery and a fold running towards the internal abdominal ring.

If inflammation should occur in an appendix overhanging the pelvic brim in the female, it may become adherent to the right ovary, and pain may occur in the right iliac fossa during menstruation. An inflamed appendix sometimes becomes adherent to the bladder or rectum, and in such cases painful micturition or defæcation may occur; and should an appendicular abscess form, it may discharge into the bladder or rectum.

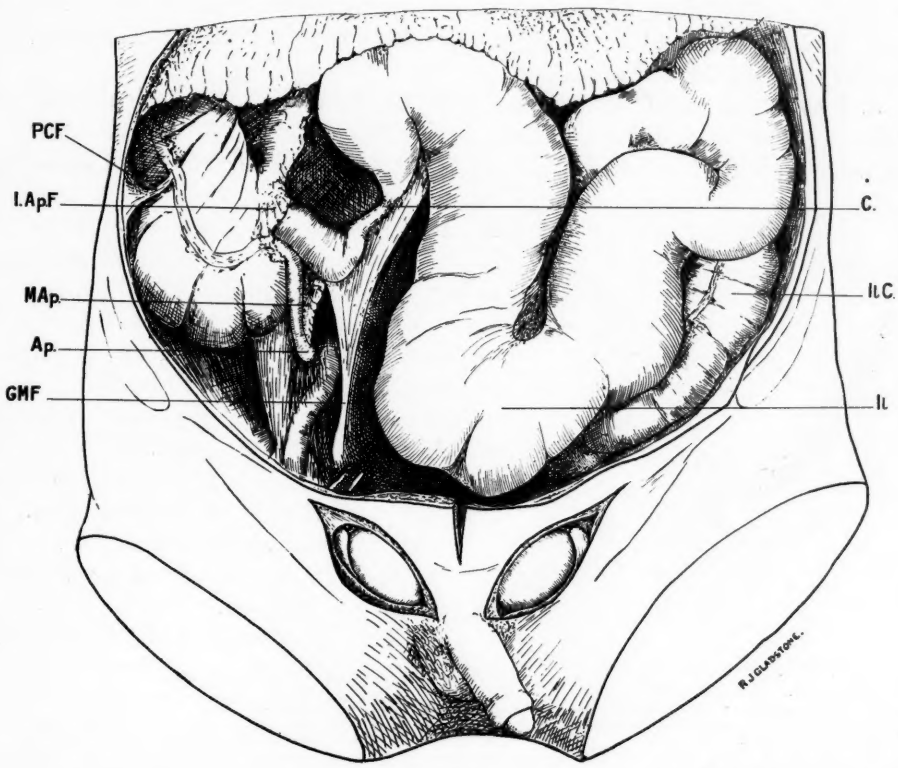


FIG. 292.—Descending position of appendix. The appendix is directed downwards, and lies on the right psoas muscle. Its tip overhangs the brim of the pelvis and is in relation with a tortuous external iliac artery. A well-developed genitomesenteric fold is present, which has caused a downward kink and constriction of the ileum. The portion of ileum proximal to the constriction was tensely distended with flatus. The testicles were incompletely descended, and the external genitalia small.

Ap., Appendix. *C.*, Constriction of ileum. *G.M.F.*, Genitomesenteric fold. *I.Ap.F.*, Ileocæcal fold. *Il.*, Distended portion of ileum. *Il.C.*, Iliac colon. *M.Ap.*, Meso-appendix. *P.C.F.* Parietocæcal fold.

4. **The 'Sub-cæcal' Position** of the appendix beneath the 'caput cæci' (*Fig.* 293) is not so uncommon as one might be inclined to think—1·86 per cent in our cases. The appendix lies in the lower part of the iliac fossa, and is usually turned to the right. It is often coiled or kinked. The ileo-appendicular fold is usually small or absent. In the specimen drawn a sharply-defined fold of peritoneum passed from the posterior surface of the ileum to the lower part of the iliac fossa, where it terminated above and to

the outer side of the external abdominal ring. It limited the sub-cæcal fossa below and internally, and probably represented a genitomesenteric fold, the upper end of which had descended with the ileum, so that the direction of the band had been changed from the vertical to the horizontal. The terminal part of the ileum in these cases is frequently found ascending from the pelvis to the ileocæcal junction, and having a direction which is in line with the ascending colon. If inflammation occurs in the appendix in this position, an abscess may form, which sometimes bursts through the fascia iliaca into the iliacus muscle, and gives rise to flexion of the hip-joint owing to spasm of the muscle. A variety of post-cæcal fossa containing the appendix has been described beneath the iliac fascia. This we consider to be produced as a secondary result of inflammation.

5. **The 'Post-cæcal' and Retrocolic Positions.**—The group including these positions is the most common in our series, there being 2076, or 69·2 per cent, This is in accord with the general experience of both surgeons and anatomists at the present time, but differs markedly from the statistics which have been published by previous writers and quoted in many of the standard text-books. This may be accounted for partly by the difficulties which arise from one group overlapping another, and partly from the subdivision of the posterior positions, which are essentially the same, into two or more groups, thus masking the true frequency of this *most common type.*

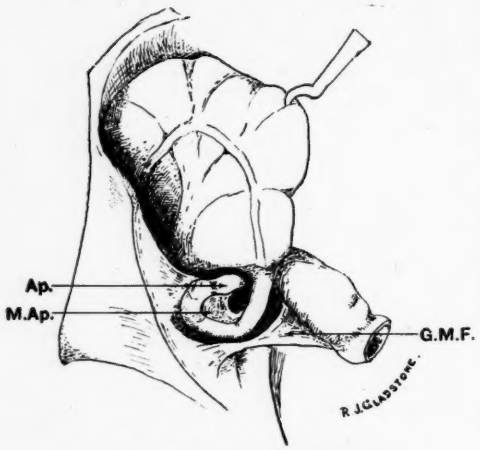


FIG. 293.—Sub-cæcal position of appendix. The appendix lies under cover of the 'caput cæci' in a post-cæcal fossa, which is limited below by a horizontally placed genitomesenteric fold.

Ap., Appendix. *G.M.F.*, Genitomesenteric fold. *M.Ap.*, Mesentery of appendix.

The appendix may be found :—

a. Free in a post-cæcal or retrocolic pouch of peritoneum.

b. Held in contact with the cæcum or the ascending colon by a short mesentery.

c. Adherent to the cæcum or colon, which, with the appendix, form the anterior wall of a retrocolic pouch of peritoneum.

d. Behind the cæcum and ascending colon, but, owing to obliteration of the retrocolic pouch, entirely extraperitoneal.

There is no doubt that inflammatory changes occurring in the appendix may cause a perfectly free appendix in position (*a*) to become adherent to the cæcum and so come into sub-division (*c*). There is also, however, a considerable amount of variation in the degree to which the cæcum and ascending colon become adherent to the posterior abdominal wall and iliac fossa in the course of normal development, apart from any secondary adhesion caused by inflammation.

As an accurate knowledge of the position of the appendix, and of the various foldings of the adjacent parts of the peritoneum during fœtal life, are essential for the explanation of the fixation of the cæcum and appendix in the normal positions in which they occur in the adult, and more especially of some

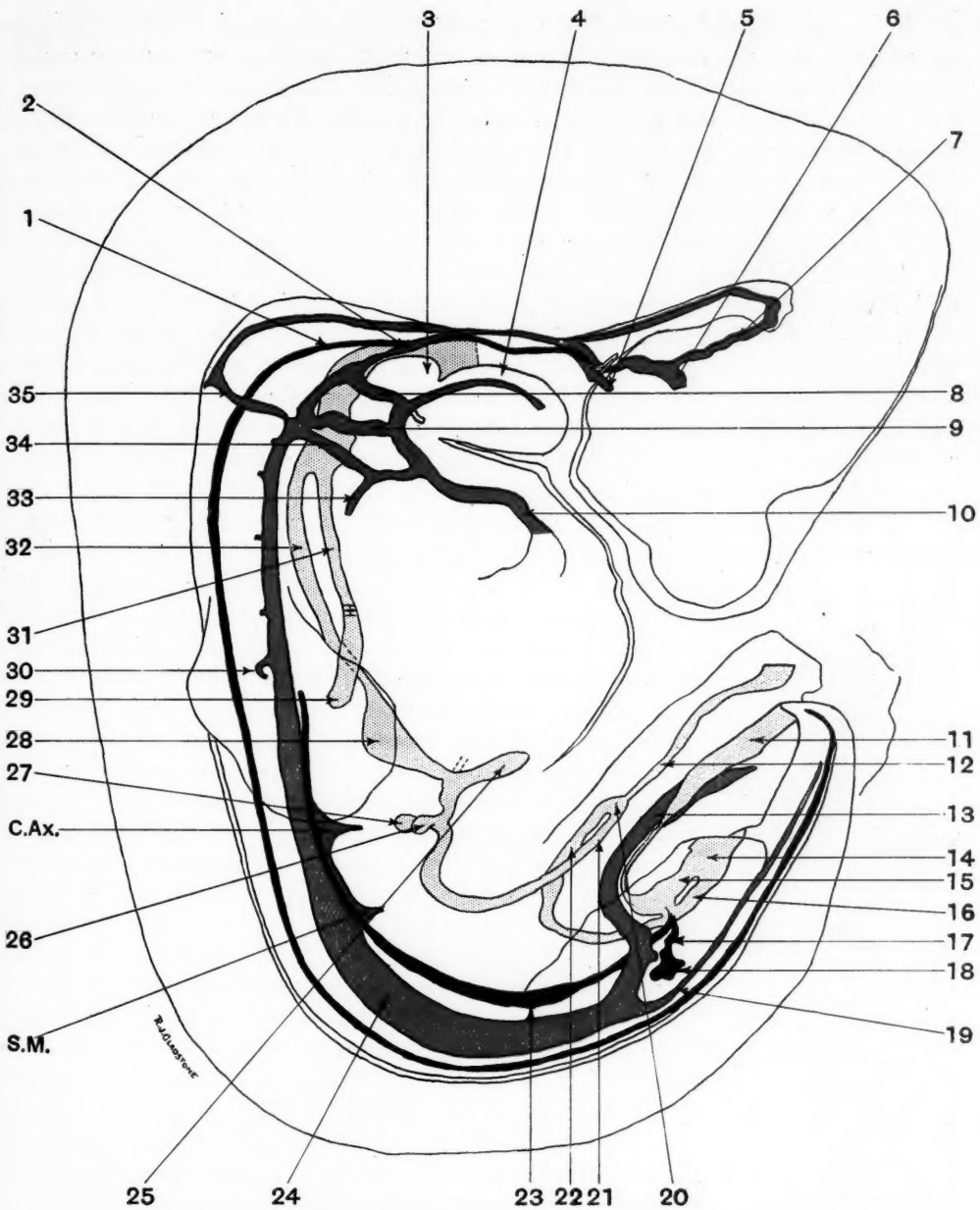


FIG. 294.—A linear reconstruction from serial sections of a human embryo, 9 mm. in length, aged about 4½ weeks. The embryo is seen at a magnification of 15 diameters. There were 407 sections, 10 μ in thickness. Every second section was drawn, and the parts shown in the drawing were plotted on 'millimetre paper'. The figure shows the cephalic or proximal limb of the umbilical loop of the intestine lying to the right of the caudal or distal limb, which it crosses near the thickening which marks the position of the future cæco-appendix and ileocæcal junction. The vitello-intestinal duct or stalk of the yolk-sac is attached to the summit of the umbilical loop.

1, Notochord. 2, Internal carotid artery. 3, Tongue. 4, Mandibular arch. 5, Ophthalmic artery. 6, Anterior cerebral artery. 7, Posterior cerebral artery. 8, Third arch. 9, Fourth arch. 10, Aorto-pulmonic trunk. 11, Allantois. 12, Vitelline duct. 13, Umbilical artery. 14, Cloaca. 15, Urethro-vesical tube. 16, Rectum. 17, Ureter. 18, Renal bud. 19, Middle sacral artery. 20, Umbilical loop. 21, Cephalic limb. 22, Caudal limb. 23, Mesonephric duct. 24, Abdominal aorta. 25, Gall-bladder. 26, Left or dorsal pouch. 27, Right or ventral pouch. 28, Stomach. 29, Right lung. 30, Subclavian artery. 31, Trachea. 32, Œsophagus. 33, Pulmonary artery. 34, Sixth arch. 35, Primitive vertebral artery. *C. Ax.*, Coeliac axis. *S.M.*, Superior mesenteric artery.

of the more unusual sites of the appendix such as the intramesenteric or extraperitoneal, we have considered it necessary to describe in some details the various phases of its development from its first appearance until birth. The unusual positions referred to may not only give rise to difficulty in finding the organ, but may predispose to obstruction, kinking, and inflammation, and a knowledge of the developmental aberration or defect which has produced a particular condition will prove of the greatest value in dealing with the condition quickly and effectively.

The early stages of development have been admirably described by Kelly and Hurdon in their work on *The Appendix Vermiformis and its Diseases*, 1905. This description is based on an investigation of 54 human embryos from the private collections of the late Franklin P. Mall and M. Max Brödel. We shall therefore merely allude to certain points of general interest which have been observed by us during its extra-embryonic stage, and shall describe more fully the later phases of its development, from the return of the intestine from the 'umbilical cœlom' into the abdominal cavity until birth.

The first indication of the ileocæcal junction occurs in embryos from 5 to 5½ weeks old and from 5 to 7·5 mm. in length. The intestine then projects forwards into the root of the umbilical cord, in the form of a wide V-shaped loop. The proximal part of this loop is continuous with the duodenal end of the foregut, and is termed the cephalic limb; the apex projects forward within the umbilical extension of the peritoneal cavity or umbilical cœlom into the root of the cord, and is continuous with the stalk of the yolk-sac; the distal part of the loop is continued into the hind-gut, and is termed the caudal limb. The loop is connected with the posterior wall of the abdomen by a dorsal mesentery, which is attached to this wall along an approximately medial line. It contains the omphalo-mesenteric or vitelline vessels, which will afterwards be represented by the single superior mesenteric artery and vein. Near the distal end of the caudal limb of the loop a slight bulging is present, which is the first indication of the cæcum and appendix, and of the junction of the small with the large intestine.

FIG. 295.—Two stages illustrating the life-history of the 'transient appendix', after Max Brödel and Mall, from *The Appendix Vermiformis and its Diseases* (Kelly and Hurdon). A represents an early phase in its development dur ing the 6th week, B an atrophic stage preceding its degeneration and disappearance from a 7-weeks embryo.

In an embryo of 9-mm. length, which has been reconstructed from serial sections by one of us (R. J. G.) after the linear projection method (*Fig.* 294), the loop of intestine is seen to project considerably farther forward into the umbilical cord, and has become twisted so that the caudal limb lies to the left and nearer the head end of the embryo, while the cephalic limb is to the right and nearer the tail. The stalk of the yolk-sac is now reduced to a narrow tube, the vitello-intestinal duct, which is attached to the summit of the loop, and at this stage helps to hold it in position.

Between the 6th and 7th weeks, in embryos of from 10-mm. to 20-mm. length, a considerable elongation of the cæcal bulging takes place, and its

longitudinal axis, at first straight, and in line with the longitudinal axis of the colon, usually becomes bent so as to form a **U**-shaped figure with the commencement of the colon. This is apparently the result of traction exerted on the cæco-appendix by its mesentery, which is drawn out from the common mesentery as the cæcum elongates. A remarkable outgrowth from the tip of the cæcum is also present at this stage of development (*Figs.* 295 and 296), which simulates in its position and form the true vermiform appendix; but since it atrophies in embryos of 20-mm. length, and afterwards completely disappears, it is believed to be an independent structure, and not connected with the permanent appendix cæci, which is differentiated later. Possibly it represents one of the two cæcal diverticula which are found in birds, and appears only as a vestigial and transitory structure in the human embryo, whereas the other develops later and persists as the permanent 'appendix cæci'.

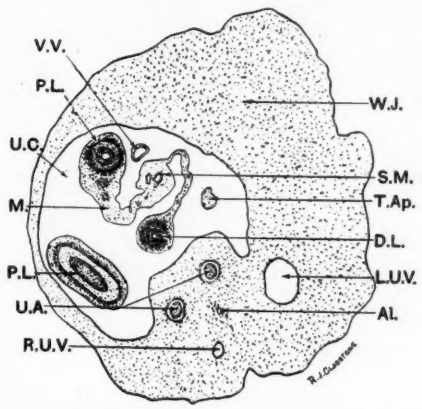


FIG. 296.—Transverse section through the umbilical cord of a human embryo 20 mm. in length, obtained from a laparotomy performed by Mr. Sidney Boyd. The 'transient appendix', *T.Ap.*, is seen to the left (right side in the drawing, the section being seen from in front) of the umbilical loop of intestine and its dorsal mesentery. No lumen is present, except at its root, where it springs from the cæco-appendix. The appendix is directed forward away from the embryo, and the portion of the distal limb of the loop, *D.L.*, below and to the right of it is the terminal part of the ileum. (Compare *Fig.* 298.)

Al., Allantois. *D.L.*, Distal limb of umbilical loop, cut near the termination of the ileum. *L.U.V.*, Left umbilical vein, already greatly exceeding the right umbilical vein, *R.U.V.*, in size. *M.*, Mesentery of small intestine containing branches and tributaries of the superior mesenteric artery and vein, *S.M.* In this position these vessels are incorporated in the mesentery, lying between its two layers; farther forward in the region of the vitello-intestinal duct they lie, like the vitelline vein, *V.V.*, free in the umbilical cœlom. *P.L.*, *P.L.*—Proximal limb of umbilical loop. *T.Ap.*, Transient appendix. *U.A.*, Umbilical arteries. *U.C.*, Cavity of umbilical cœlom. *W.J.*, Whartonian jelly.

In the succeeding 8th and 9th weeks, the part of the umbilical loop which gives rise to the small intestine increases enormously in length and becomes massed in coils beneath the cæco-appendix and commencement of the colon, which lie above and to the left. The return of the intestine from the umbilical cœlom into the abdominal cavity takes place in embryos of about 40 mm. length and 10 weeks of age. The small intestine slips back first and occupies a position to the right of the intra-embryonic mesocolon, while the cæco-appendix with the commencement of the colon, which lie above the small intestine in the umbilical cœlom, return last, and assume a subhepatic position near the middle line, below and to the right of the umbilical vein. The mechanism of this return of the alimentary canal into the abdominal cavity, and the relative positions which are subsequently assumed by the large and small intestines, have been well described by Professor J. E. Frazer and Dr. R. H. Robbins in an article entitled "Factors concerned in causing the Rotation of the Intestine in Man." *

The typical relations of the cæco-appendix soon after the return of the

* *Journal of Anatomy*, 1915, l, 75.

intestines into the abdomen are well seen in *Fig.* 297, which is a drawing, taken from in front, of a model reconstructed by one of us (R. J. G.) according to the wax-plate method of Born, from serial sections of a 45-mm. human

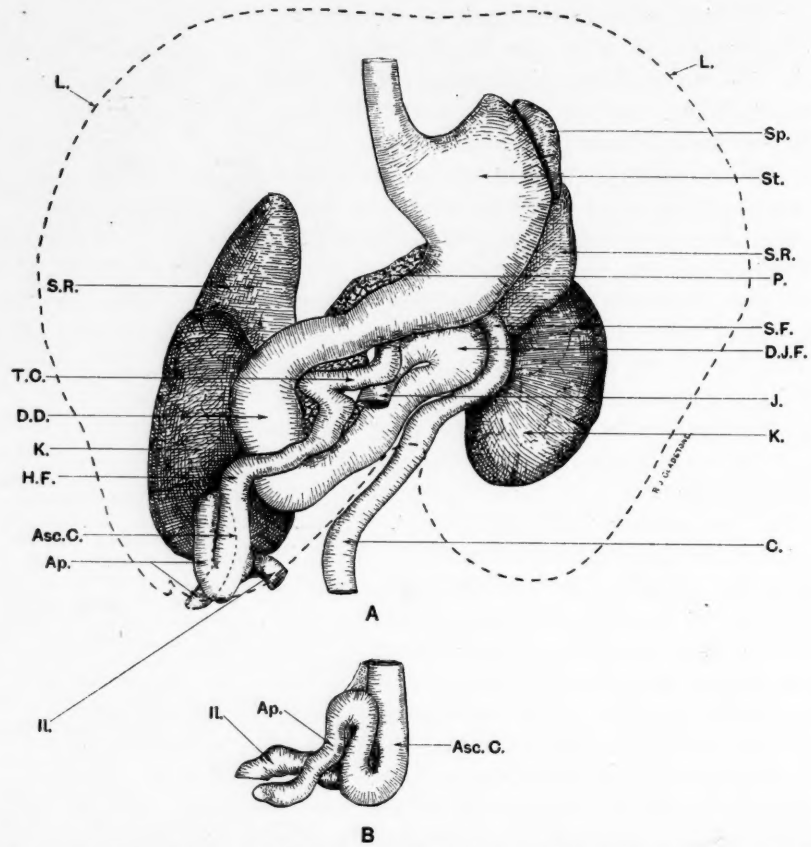


FIG. 297.—A, Drawing of a model, reconstructed from serial sections of a 4·5-cm. human embryo, showing the relative positions of the viscera in the upper part of the abdominal cavity. The outline of the liver, *L.*, is represented by an interrupted line. It will be noted that the ascending colon, which is very short, lies entirely under cover of the liver, and in front of the lower part of the right kidney a wide angle marks the position of the hepatic flexure of the colon, which lies between the cæco-appendix and duodenum. Thence the transverse colon passes obliquely upwards and to the left, across the descending duodenum, head of pancreas, and commencement of the jejunum, to the left suprarenal body. Here it forms a loop behind the pyloric part of the stomach (splenic flexure). This loop lies a considerable distance below the level of the spleen, which has not yet grown down to its permanent position relative to the left suprarenal body and kidney. The descending colon then passes obliquely downwards and to the right below the obliquely placed third portion of the duodenum. The ileocæcal junction lies just below the lower end of the right kidney, and is separated from the posterior abdominal wall by coils of ileum. The liver lies to the right and in front; coils of intestine lie in front of, as well as behind, the cæcum and appendix. (*See Fig.* 299, which is a drawing of a section from the series used in the construction of the model, taken just below the inferior pole of the right kidney.)

B represents the cæcum and appendix, viewed from the right, and shows the ∩-shaped bend, the terminal part of the ileum, and ascending colon.

embryo. The position of the liver is indicated by an interrupted line. It will be seen that the cæco-appendix has moved to the right of the median plane and lies under cover of the right lobe of the liver. It is coiled in the form of a ∩-shaped bend. The proximal limb of the loop runs upward from

the ileocæcal junction behind the colon; it then turns backwards, forming the summit of the ∩-shaped bend, and finally downward as the descending limb which terminates in a free extremity, the tip of the appendix, which appears just below the inferior border of the liver. It is situated just below the ileocæcal junction, and above the highest point of the iliac crest, at the level of the body of the 4th lumbar vertebra. The differentiation of the cæcum from the appendix has not yet taken place. It is probable, however, that the future cæcum is represented by a slight bulge of the large intestine immediately below the ileocæcal junction, and that the whole of the ∩-shaped bend will give rise to the appendix. The ileum passes forward medial to the cæco-appendix, and enters the colon from below and to the left (*Fig.* 299). Thus, the rotation of the ileocæcal junction from its primary position, which is on the right of the colon (*Fig.* 298), to its permanent position behind and to the left, has already taken place. This rotation is due to the movement of the cæco-appendix from the median place in which it lies at the time of its entrance into the abdomen, in a direction downward and to the right, beneath the liver, combined with a movement of the terminal part of the ileum with its mesentery in the reverse direction from right to left. At this stage the lower part of the right lobe of the liver is lateral to the cæco-appendix (*see Fig.* 299) and the commencement of the colon, and coils of small intestine lie behind, and thus separate them from the posterior abdominal wall and right kidney (*Fig.* 299); moreover, the attachment of the common mesentery of the small intestine and colon is still approximately mesial. In

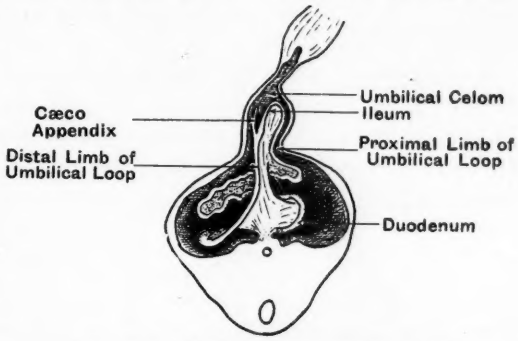


FIG. 298.—Drawing representing the lower half of the trunk and a portion of the umbilical cord seen from above. Slightly modified from Frazer and Robbins. The figure shows diagrammatically the relation of the terminal part of the ileum to the cæco-appendix and the commencement of the colon. The cæco-appendix lies above the coils of the small intestine, and these authors believe that it is the last part of the loop to return into the abdominal cavity. This diagram should be compared with *Fig.* 296, which depicts a transverse section of the umbilical cord just beyond the tip of the cæco-appendix.

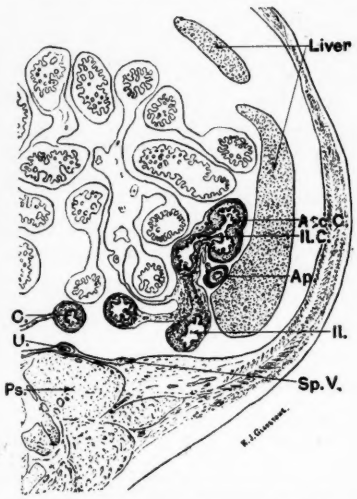


FIG. 299.—A camera lucida drawing through the ileocæcal junction, from one of the sections of the 4·5-cm. embryo from which the model, *Fig.* 297, was reconstructed. The descending limb of the ∩-shaped cæco-appendix lies between the terminal part of the ileum and the right lobe of the liver, and coils of intestine intervene between the cæco-appendix and the posterior abdominal wall. The descending colon and its mesentery (the future pelvic colon) are seen in front of the psoas muscle and ureter, and to the right of the latter are the spermatic vessels lying in the 'plica vascularis'.

Ap., Appendix. *Asc.C.*, Ascending colon. *C.*, Descending colon. *Il.*, Ileum. *Il.C.*, Ileocæcal orifice. *Ps.*, Psoas major. *Sp.V.*, Spermatic vessels. *U.*, Ureter.

the duodenal region, however, the root of the mesentery is curved towards the right, and is continuous with the mesocolon, where the mesenteric pedicle turns anti-clockwise round the axis of the superior mesenteric artery; the mesocolon thus crosses the head of the pancreas and the descending part of the duodenum, as in the adult, though the omental bursa has not yet become adherent to the transverse colon and its mesentery. Since coils of intestine intervene between the cæco-appendix and the posterior abdominal wall, and there is a long mesocolon, the cæcum is free to move in a downward direction into the iliac fossa. In the 45-mm. embryo from which the model has been reconstructed, it already lies just above the level of the iliac crest, although it is almost completely under cover of the right lobe of the liver. The position of the cæco-appendix at this stage appears to vary considerably in different specimens. This is largely due to the degree of rotation that has taken place at the ileocolic junction; thus, in a 45-mm. embryo figured by Frazer and Robbins, the ileum enters from the right side, and the appendix is directed upwards in front of it; in another specimen representing a later stage the ileum enters the colon from below, and the appendix is directed horizontally to the right; in our own specimen the rotation is complete, the ileum enters from behind and from the left (*Fig.* 297), and the appendix is retrocolic in position (*Fig.* 299).

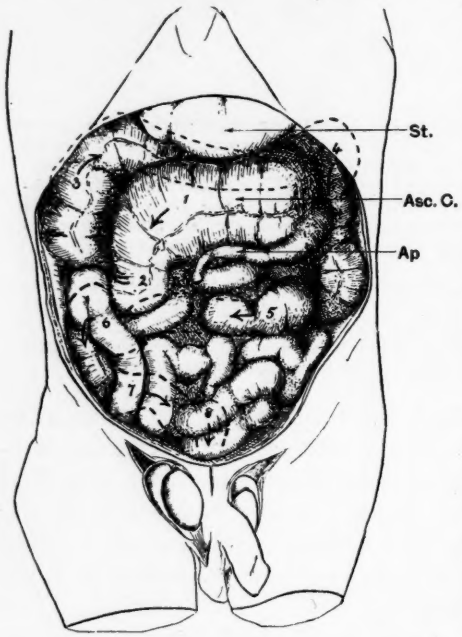


FIG. 300.—Ectopic position of the cæcum and appendix, from a dissecting-room subject in which the testes were imperfectly descended. The cæcum and appendix were free, and displaced upwards and to the left beneath the stomach, in front of and below the transverse colon, which is represented by the dotted lines between 3 and 4; the hepatic flexure lies between 2 and 3; the splenic flexure at 4. The loop formed by the 'pelvic colon' remains in the fœtal position, namely, in the lower part of the abdomen and right iliac fossa; its course is represented by the dotted lines and arrows 5, 6, 7; it lay for the most part behind the small intestine, except for a small portion indicated by the arrow between 6 and 7, where it occupied the right iliac fossa.

Should coils of small intestine remain between the right lobe of the liver and the cæco-appendix, this, with the proximal part of the colon, may be pushed to the left (*Fig.* 300) and take up a position beneath the stomach and transverse colon, with the tip of the appendix directed to the right and lying below the proximal part of the colon, which courses horizontally from left to right, instead of ascending in the right lumbar region to the liver.

At this stage, immediately after the rotation of the terminal part of the ileum with its mesentery beneath the cæcum and the proximal part of the colon, which are carried to the right, an angle is formed between the mesocolon carrying the right and middle colic arteries and the terminal part of the mesentery of the small intestine enclosing the vasa intestini tenuis; at the apex of this >-shaped bend is the

ileocolic artery, which sends an anterior cæcal branch in front of the ileocolic junction, and a posterior branch behind the ileum to the posterior surface of the cæco-appendix. This branch runs in the mesentery of the cæco-appendix and persists as the appendicular artery, which in the adult runs near the free border of the meso-appendix. Should the appendix become caught in the receding angle between the two laminæ of the >-shaped fold, it will be held in are troperitoneal position at the root of the mesentery, ('intramesenteric position'*), or it may lie in the anterior wall of a retrocolic or retro-ileal pouch; and should the pouch become obliterated by adhesion and absorption of its walls, the appendix will be completely extraperitoneal. In the latter case it may be readily exposed bydividing the peritoneum below the cæcum and carefully raising the 'caput cæci' fromthe iliac fossa.

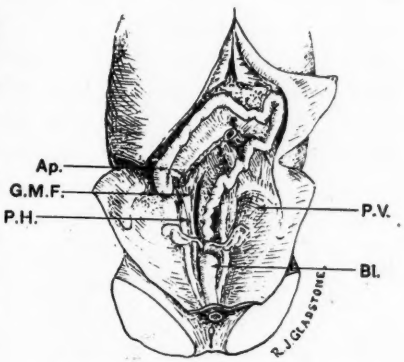


FIG. 301.—Drawing of a dissection showing the cæcum and appendix lying at the level of the right iliac crest, and the position of the colon and its mesentery in a fœtus at the end of the third month. The small intestine has been removed so as to show the root of the mesentery and the mesocolon. The appendix was directed upwards behind the ileocæcal junction and ascending colon. A genitomesenteric fold passed from the posterior aspect of the broad ligament and the brim of the true pelvis upwards over the 'plica hypogastrica' and right psoas major to the posterior aspect of the mesentery of the small intestine. It had a free border directed to the right, and a wide basal attachment corresponding internally to the line of the ovarian vessels. Its lower part and root of attachment therefore correspond to the 'plica vascularis'. A similar fold is present on the left side, which in the later stages of development would be covered and obliterated in the greater part of its extent by the growth over it of the pelvic mesocolon.

Ap., Appendix. *Bl.*, Bladder turned downwards with the anterior wall of the abdomen. *G.M.F.*, Genitomesenteric fold. *P.H.*, Plica hypogastrica. *P.V.*, Plica vascularis ($\frac{1}{8}$in. beyond arrow).

Connected with the lower surface of the mesenteric laminæ of the >-shaped bend is an important fold of the peritoneum which runs vertically downwards to the brim of the true pelvis and vicinity of the future internal abdominal ring (*Figs.* 290–293 and 301). This fold has been described by various authors under different names, of which perhaps the best is the 'genitomesenteric'. Its connections have been described by R. Douglas Reid in several articles recently published in the *Journal of Anatomy and Physiology*, and he believes it to he instrumental in causing the descent of the mesentery of the small intestine, with a consequent lowering of the mesenteric root; he also states that it is the commonest cause of a retrocolic position of the appendix. The fold is usually triangular, having an anterior surface directed forward and to the left, a posterior surface directed backwards and to the right. Of the three borders, two are fixed and one is free. Thus, there is usually a posterior fixed border attached to the posterior abdominal wall and extending from the duodenal region downwards on the right psoas muscle to the pelvis; an upper attached border connected with the under surface of the mesentery of the small intestine near the ileocæcal orifice, or with the ileum in the same situation; and a free border

* An interesting example of the intramesenteric position of the appendix has been recorded by Nicola Novaro, in the *Gaz. d. Osp.*, 1921, xlii, 147.

usually directed forward and to the right. The lower end of the fold in the female passes over the brim of the pelvis, on to the posterior aspect of the broad ligament of the uterus, and is frequently blended with the suspensory ligament of the ovary. In the male, it may end in the neighbourhood of the internal abdominal ring, or pass over the brim of the pelvis to the lower end of the fold raised by the obliterated hypogastric artery. The genitomesenteric fold may contain between its layers a thick stratum of extraperitoneal connective tissue, which in some cases forms a traction band of considerable strength; it may thus give rise to kinking and constriction of the terminal part of the ileum, or a displacement downwards and inwards of the ileum, and with it the cæcum and appendix.

Various factors appear to be concerned in the formation of this fold. Of the folds which are present in the embryo, we may consider first the 'urogenital mesentery'. This connects the genital gland and mesonephros (Wolffian body) to the posterior abdominal wall (*Fig.* 302). It is continuous at its upper end with the 'plica vascularis' or diaphragmatic ligament, and in the pelvic region is connected by the inguinal fold containing the gubernaculum with the internal abdominal ring. Following the degeneration which takes place of the upper part of the mesonephros and genital gland, there is also a degeneration and apparent displacement downwards of the diaphragmatic ligament as far as the origin of the internal spermatic or ovarian vessels which descend in the fold—now known as the 'plica vascularis'—to the testicle or ovary. The lower end of the fold persists in the adult female as the ovariopelvic ligament, or suspensory ligament of the ovary, with which the genitomesenteric band is frequently incorporated; and in the male passes downwards on the external iliac vessels to the internal abdominal ring, with which the lower end of the fold is sometimes associated, as in a case of patent 'processus vaginalis' in an adult male described by Douglas Reid* in 1913. In this case, as in the specimens represented in *Figs.* 290, 291, and 293, the genitomesenteric fold formed the left boundary of a retrocolic fossa. In Reid's case, the appendix, which was in contact with the right or posterior surface of the 'plica genitomesenterica', could not be withdrawn from the fossa on account of an adhesion of its mesentery to the genitomesenteric fold.

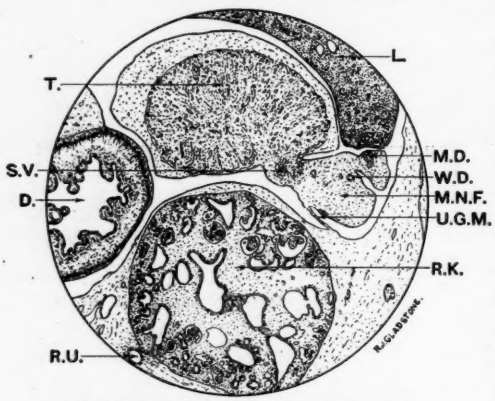


FIG. 302.—Camera lucida drawing of a transverse section through a 35-mm. human embryo, showing the relations of the testis and mesonephric fold to the duodenum, kidney, and liver.

D., Duodenum. *L.*, Liver. *M.D.*, Mullerian duct. *M.N.F.*, Mesonephric fold. *R.K.*, Right kidney. *R.U.*, Right ureter. *T.*, Testis. *S.V.*, Internal spermatic vessels. *U.G.M.*, Urogenital mesentery. *W. D.*, Wolffian duct.

On the left side, the upper part of the 'plica vascularis' is, in the normal course of development, obliterated by the adhesion of the left side of the

**Journal of Anatomy and Physiology*, xlvii, 479.

primitive mesocolon to the peritoneum covering the posterior abdominal wall. When the descending and iliac portions of the colon are carried to the left by the pressure of the enlarging coils of small intestine which fill the concavity of the ∩-shaped curve of the colon, the 'plica vascularis' is completely covered over by the mesocolon, and disappears. A similar obliteration of the upper part of the 'plica vascularis' takes place on the right side, owing to the folding over of the mesentery of the ascending colon and terminal part of the ileum, and its adhesion to the peritoneum on the right side of the posterior abdominal wall. On the right side, however, the obliteration is not so extensive, owing to the lower attachment of the mesentery of the small intestine being at a considerably higher level than that at which the iliac colon crosses the brim of the pelvis to become continuous with the pelvic colon on the left. The primary position of the plica is well seen in *Fig.* 301, in which the colon is still almost medial in position. The small intestine has been cut away so as to show the relation of the upper end of the genitomesenteric fold to the posterior surface of the mesentery of the small intestine. It will be seen to cross the fold raised by the hypogastric artery, and the free border is directed to the right. The relationship of the 'plica vascularis' to the posterior abdominal wall in a 4·5-cm. human embryo is well seen in *Fig.* 299. It lies in front of the psoas muscle, and contains the spermatic vessels between its layers. The position of the urogenital fold and internal spermatic vessels at an earlier stage (35 mm.) is shown in *Fig.* 302, in which adhesion has not yet taken place. It will be observed that the genital gland and mesonephric fold are connected to the posterior abdominal wall by a thin mesentery, which, as it is common to the genital gland and mesonephros, is termed the 'urogenital mesentery'. The testis is lying in the same horizontal plane as the permanent kidney, liver, and duodenum. Sections of the spermatic vessels are cut across in the hilum (mesogenitale) of the testis, and to the right is seen the degenerating Müllerian duct, lying in the free border of the tubal part of the fold. The Wolffian duct and some of the epigenital tubules of the mesonephros are cut across in the glandular part. Felix has shown that the apparent descent of the genital glands, mesonephroi, and Wolffian ducts in the early stages of development is due to a degeneration of the upper (cranial) portion, which occurs simultaneously with the growth of the lower (caudal) pole. Accompanying this degeneration of the structures contained in the urogenital fold is a descent of the diaphragmatic ligament as far as the level of the lowest 9 to 11 pairs of mesonephric arteries which are present in a 19-mm. embryo, and which are represented in the adult by the internal spermatic or ovarian arteries; these are contained in the urogenital fold, and extend from their origin from the abdominal aorta, at the level where this vessel is crossed by the duodenum, to the genital gland. The fold of peritoneum in which they lie is now spoken of as the 'plica vascularis'; this corresponds in its upper part, where it lies on the psoas muscle, to the line of attachment of the genitomesenteric fold, and ends below in the genital gland. It appears probable, therefore, that the genitomesenteric fold originates from that part of the urogenital fold which contains the definitive internal spermatic or ovarian arteries. The position of the spermatic vessels on the psoas muscle as seen in *Fig.* 299, and the appearance of the

border of a peritoneal fold to the outer side of these vessels, give the impression that degeneration of the urogenital fold above the level of the testis has not been complete, and that the fold has become adherent to the peritoneum covering the psoas muscle. At a later stage of development the mesentery of the terminal part of the small intestine and commencement of the colon will adhere to this part of the peritoneum, which, should the view expressed above be correct, affords a ready explanation of the relation of the upper end of the genitomesenteric fold to the posterior surface of the mesentery of the ileum in this position, and its connection below with the suspensory ligament of the ovary or—in the male—the upper end of the inguinal canal.

The upper part of the genitomesenteric fold thus appears to originate from an adhesion of the ileac mesentery to the right 'plica vascularis' and remnant of the mesonephric fold; and its lower part appears to be related in the male subject to the inguinal ligament and gubernaculum testis, and in the female to the suspensory ligament of the ovary. It is probable also, as has been suggested by R. Douglas Reid, that by its traction on the ileum the band is instrumental in causing the descent of the cæcum and appendix into the right iliac fossa.

The strong bands that are sometimes present in this situation in adult and more especially aged subjects (*Figs.* 290 and 292), and which may give rise to kinking and obstruction of the ileum, are obviously due to an abnormal development of fibrous and muscular tissue within the normal fold. The abnormal development or hypertrophy of the sub- or extra-peritoneal tissue may be explained, as has been demonstrated by Arbuthnot Lane, on the assumption that forces, such as peristaltic action, or gaseous distension of the intestine, exert traction which is resisted by the development of a band which will act as a counteracting force in the opposite direction. Should these forces, as frequently happens, be exerted along the line of the normal fold as described above, this fold will become exaggerated, and the extraperitoneal tissue between its layers will become hypertrophied and condensed so as to form a strong 'retention band' capable of causing displacement and obstruction of the intestine.

We do not propose in this paper to describe variations in the form of the cæcum and appendix, nor to refer further to peculiarities in the position of the various folds and fossæ associated with this region. These have been ably and exhaustively described by various authors, reference to whom, along with detailed descriptions, will be found in articles by Sir Frederick Treves, Douglas Reid, and in Kelly and Hurdon's *The Vermiform Appendix and its Diseases.*

Among the rarer conditions of the cæcum and appendix which are of surgical interest, we may, however, refer to two important abnormalities, namely: (1) Congenital absence of the appendix; (2) Its position in the left iliac fossa in transposition of the viscera. An example of the former was described by one of us, in 1916, in the *Journal of Anatomy and Physiology.* The condition is extremely rare. No instance of it has occurred in the 3000 cases on which our classification has been based; and in another series

of 1352 systematic observations, only one example, recorded by Fawcett and Blatchford, occurred. Several other cases, however, have been published or preserved in museums. These illustrate arrest of development at different stages, namely : " Absence of the cæcum and appendix " (Robinson). " Rudimentary cæcum without appendix " (Sutton and Chill). " Blunt, conical cæcum without appendix " (Huntington). " A cæcum having a rounded symmetrical form, with the longitudinal muscular bands converging towards its apex, but without appendix " (Huntington). " Asymmetrical form without appendix " (Gladstone).

The position of the cæcum and appendix in the left iliac fossa associated with general transposition of the viscera, although rare, is of sufficient practical importance to merit a brief notice in this article. As was the case in absence of the appendix, no instance of this abnormality has occurred in our 3000 observations. One of us, however, when a student attending the Pathological Department of the General Hospital, Vienna, met with an example of general transposition of the viscera in a female child, age 18 months, who died from pyæmia secondary to scarlet fever, and through the kindness of the acting Professor of Pathology, Herr D'Albrecht, was enabled to obtain the specimen for the Middlesex Hospital Museum. It presented the ordinary characters of complete transposition ; the cæcum and appendix, however, lay at the level of the iliac crest under cover of the large *left* lobe of the liver, as they had not fully descended into the left iliac fossa.

Apart from these cases of transposition of the viscera, ectopic positions of the cæcum and appendix may usually be explained under one of the following headings : (1) Arrest of their descent towards the right iliac fossa. (2) Continuation of their descent beyond the normal limit, into the pelvis or into a hernial sac. (3) Deflection to some abnormal position—usually to the left—associated with a failure in the adhesion of the cæcum and ascending colon to the posterior wall of the abdomen, and retention of the primitive dorsal mesentery.

In addition to the above-mentioned congenital causes of ectopia, displacement may occur as the result of a loaded cæcum, giving rise to a low pelvic position, and other pathological conditions such as visceroptosis.

In concluding this account the authors consider that a brief reference is necessary to the statistics dealing with the position of the appendix by previous observers, which appear to differ markedly from their own series. In some cases this may be explained by different methods of classification. For example, M. Lafforgue (*Anatomie Humaine*, Testut), from an examination of 200 cases, of all ages and both sexes, records the following percentage of frequencies :—

Ascending type	.. .. ..	13 per cent
Descending type	.. .. ..	41·5 ,,
Lateral and internal type	.. ..	26 ,,
Lateral and external type	.. ..	17 ,,
		97·5 ,,

Of his atypical rare cases, the appendix was twisted round the ileum in one case, and round the cæcum in another

The classification is here based on the direction of the tip or longitudinal axis of the appendix, rather than on its position relative to the ileum, cæcum, pelvic brim, or peritoneal fossæ. In comparing these figures with the authors' series, it is probable that the 13 per cent grouped together in Lafforgue's ascending type would have included, in addition to the authors' pre-ileal and 'splenic' or post-ileal types, a considerable number of the post-cæcal and retrocolic cases in which the tip of the appendix happened to have been directed upwards in a retrocolic fossa. The descending type (41·5 per cent) would have included, in addition to the authors' 'pelvic' or descending type, a certain number of the sub-cæcal and post-cæcal types. The discrepancy, therefore, is obviously not so great as might be supposed.

From the clinical standpoint, however, the classification of the position of the appendix adopted in this article appears to be the more practical, since the appendix is often coiled or kinked (*Figs.* 291 and 293), and also since, from the surgical standpoint, the relations are often essentially different. For example, an ascending pre-ileal appendix, lying free in the peritoneal cavity, is totally different from an ascending retrocolic appendix confined in a fossa behind the colon, or perhaps extraperitoneal.

In conclusion, we wish to emphasize the frequency with which we have found the appendix lying in the post-cæcal and retrocolic positions, namely, in 69·2 per cent of the total number of 3000 cases. We regard this, therefore, as the typical and most common position of the appendix, and the descending or 'pelvic' type as the next in order of frequency.

BIBLIOGRAPHY.

CONNELL, F. G., "Etiology of Lane's Kink, Jackson's Membrane, and Cæcum Mobile", *Surg. Gynecol. and Obst.*, 1913, April, 353.

EASTMAN, J. R., "The Fœtal Peritoneal Folds of Jonesco, Treves, and Reid, and their Probable Relation to Jackson's Membrane and Lane's Kink", *Surg. Gynecol. and Obst.*, 1913, April, 341.

FELIX, W., *Manual of Human Embryology*, Keibel and Mall, 1912, ii, 823, 940.

FRAZER, J. E., and ROBBINS, R. H., "On the Factors Concerned in Causing Rotation of the Intestine in Man", *Jour. of Anat. and Physiol.*, 1915, l, 75.

GLADSTONE, R. J., "Congenital Absence of the Appendix Vermiformis", *Jour. of Anat. and Physiol.*, 1916, xlix, 414.

HURDON, E., *vide* KELLY, H. A.

KELLY, H. A., and HURDON, E., *The Vermiform Appendix and Its Diseases*, 1905.

LANE, ARBUTHNOT W., *The Operative Treatment of Chronic Intestinal Stasis*, 1915, 3rd ed.

LAFFORGUE, M., *vide* TESTUT, L.

MAYO, C. H., "Intestinal Obstruction due to Kinks and Adhesions of the Terminal Ileum", *Surg. Gynecol. and Obst.*, 1911, March, 227 .

NOVARO, NICOLA, "Su l'appendice ileo-cæcale a sede intramesenterica", *Gaz. d. Osp.*, 1921, xlii, 147.

REID, DOUGLAS G., "Studies of the Intestine and Peritoneum in the Human Fœtus", *Jour. of Anat. and Physiol.*, 1911, xlv, 73, 406; "Notes on the Folds of Peritoneum connected to the Appendix, and a Cæco-appendicular Fold", *Jour. of Anat. and Physiol.*, 1912, xlvi, 239; "Notes on the Retrocolic Fossa, Splenic Process of Peritoneum, and Bloodless Fold of Treves", *Jour. of Anat. and Physiol.*, 1913, xlvii, 479.

ROBBINS, R. H., *vide* FRAZER, J. E .

TREVES, F., Hunterian Lectures, 1885, "The Anatomy of the Intestinal Canal and Peritoneum in Man", *Brit. Med. Jour.*, 1885.

TESTUT, L., *Anatomie Humaine*, 1905, iii.

WAKELEY, C. P. G., "A Hundred and Twenty Cases of Acute Appendicitis treated by Operation". *Lancet*, 1919, ii.

SOME POINTS IN THE SURGERY OF THE PITUITARY GLAND.

By PERCY SARGENT, London.

(A Contribution to the Discussion upon the Surgery of the Endocrine Glands at a Meeting of the Sixth Congress of the International Society of Surgery, held in London in July, 1923.)

Few things in medicine are more striking than the interest which, during the past few years, has been excited by the endocrine glands. The mystery of their functioning, and the fascinating therapeutic possibilities which increasing

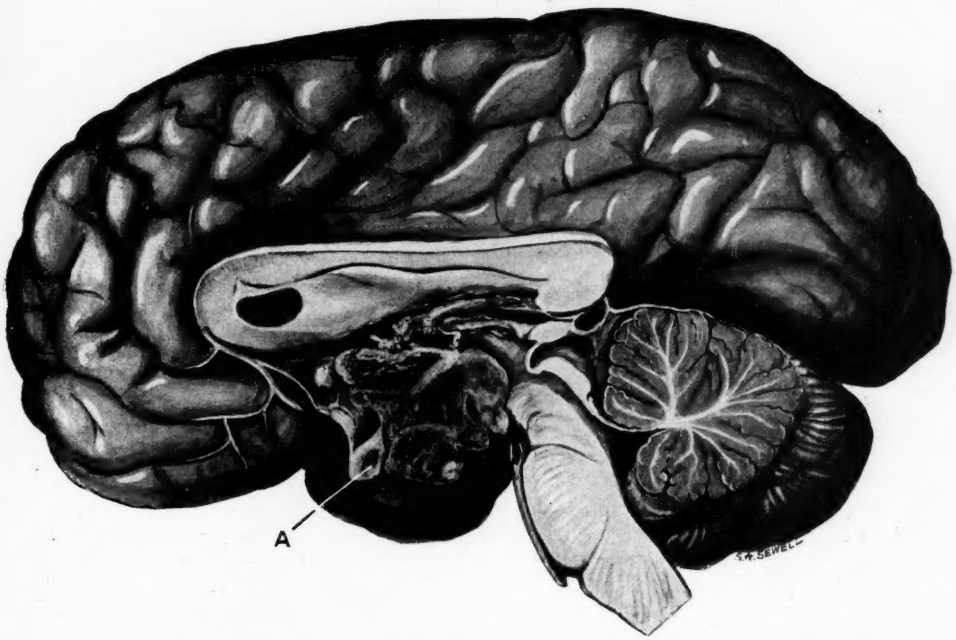


Fig. 303.—*Case* 23. Infundibular tumour, displacing the optic chiasma downwards, attached to the floor of the third ventricle, and appearing to arise from the upper part of the infundibulum. Except at its attachment it was surrounded by a capsule. It was semi-cystic and contained yellow albuminous fluid with numerous cholesterin crystals and some calcareous matter. The sella turcica was greatly enlarged; the pituitary body was of normal size, though flattened. The patient was an undersized boy, 10 years of age, with partial bitemporal hemianopia and papillœdema. A simple decompression was followed by great general improvement and increase of visual acuity. A month later the tumour was exposed, and partially removed, but death occurred within a few hours. A, Optic nerve.

knowledge suggests, strike the imagination in a peculiar manner. The testicle, under the euphemism of 'monkey gland', figures in dinner-table conversation; rejuvenation by some unspecified hormonic means has formed

the basis of a recent novel; and manufacturing chemists compete with one another in advertising elixirs distilled from any and every internal organ. Although speculation has far outrun knowledge, the past few years have nevertheless been marked by a substantial accumulation of facts regarding the physiology of the normal and the pathology of the diseased endocrine glands, and in this advance surgery has had its share. The operative treatment of exophthalmic goitre, for instance, although many questions connected with it are still unsettled, has been established upon a firm footing. The same cannot, however, be said at present of the surgery of the pituitary gland. Although there exist many resemblances between the thyroid and

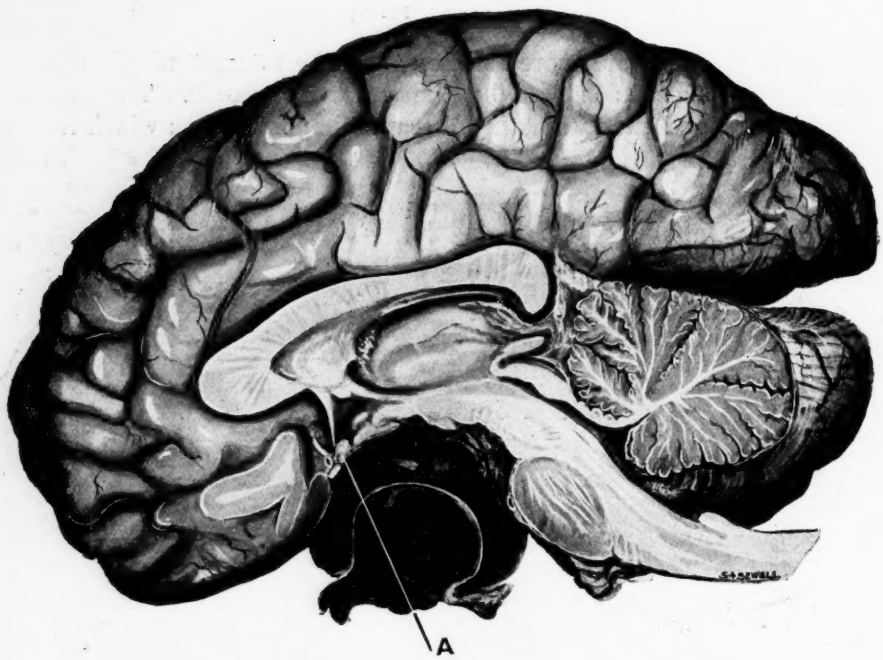


FIG. 304.—*Case* 26. Adenoma. The patient was a man 35 years of age, who complained of failing vision for two years. 'Hypopituitary' symptoms had commenced a year earlier. The left eye was blind, and only a small part of the nasal field of the right eye remained. Frequent severe headaches. A large amount of soft tumour was removed, and all went well until pneumonia supervened, from which death occurred on the twelfth day. The tumour has been pulled downwards to show the position of the optic chiasma and tract. A, Optic chiasma.

the pituitary, the comparison must not be pressed too far, and certainly from the surgical point of view the two glands must be approached differently. Each, when diseased, may cause two distinct groups of symptoms; those due to disordered function, and those due to enlargement. But whilst an enlarged thyroid sometimes requires surgical measures for the relief of dyspnœa, it is far more often operated upon either for cosmetic reasons or because of glandular symptoms. The pituitary, on the other hand, causes serious pressure symptoms which call for relief quite apart from any functioning of the gland; and, indeed, few operations can ever have been performed

for the relief of dyspituitarism unaccompanied by any other symptoms. Cushing[1] relates a case in which glandular symptoms were considerably modified after a pituitary operation of this kind. The patient was a male acromegalic with a history extending over eight years. A partial removal of the pars anterior by the nasal route was followed by immediate cessation of the headaches, and three months later there was a well-marked change in the patient's appearance. When we are dealing with cases which are at the present time conveniently regarded as hypopituitarism, it is possible that an operation which relieved pressure upon any remaining normal gland tissue by emptying a cyst, by removing a mass of adenomatous tissue, or by merely

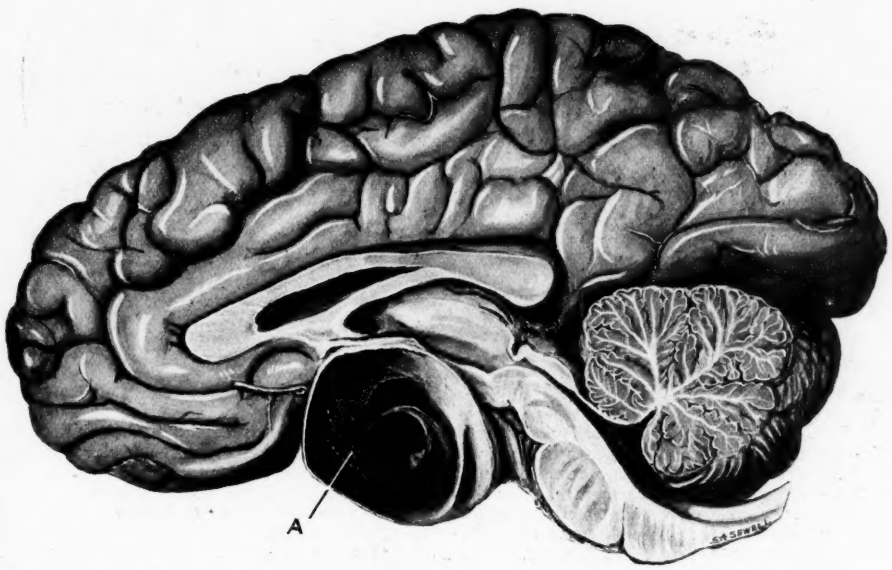


FIG. 305.—*Case* 15. An infundibular cholesterin cyst. The patient was a girl, 18 years of age, exhibiting well marked ' hypopituitary ' symptoms. Headache and visual deterioration had been noticed for two years. The cyst was emptied by aspiration. She died twelve days later, having exhibited remarkable toxic symptoms since operation. She was restless, talking incessantly, and at times maniacal ; the temperature remained high, reaching 106°, and an urticarial rash appeared. Post mortem, the cyst was attached to the base of the infundibulum and floor of the third ventricle, whilst the optic chiasma and nerves were displaced downwards. A, Optic nerve.

incising the dural capsule, might be beneficial. I have, indeed, seen a remarkable improvement in appearance take place several years after the emptying of a pituitary cyst in a man who exhibited a mixture of symptoms of acromegaly and infantilism, but whether the improvement is to be attributed to the effects of the operation, or to some obscure spontaneous changes, it is impossible to say.

Up to the present, surgery has been little concerned with the functional vagaries of the pituitary gland, except in so far as they may assist in the diagnosis of gross pituitary disease. Possibly in the future the hyperactive gland may be removed, as is now the practice in the case of the thyroid for Graves' disease, or pituitary glands may be successfully grafted into the subjects of hypopituitarism ; but at present the chief concern of surgical

intervention as regards the pituitary is to relieve symptoms of local or general pressure caused by tumours or other enlargements of the gland.

So hazardous are pituitary operations that, if anything is to emerge as regards surgical intervention for glandular symptoms, it must do so as a

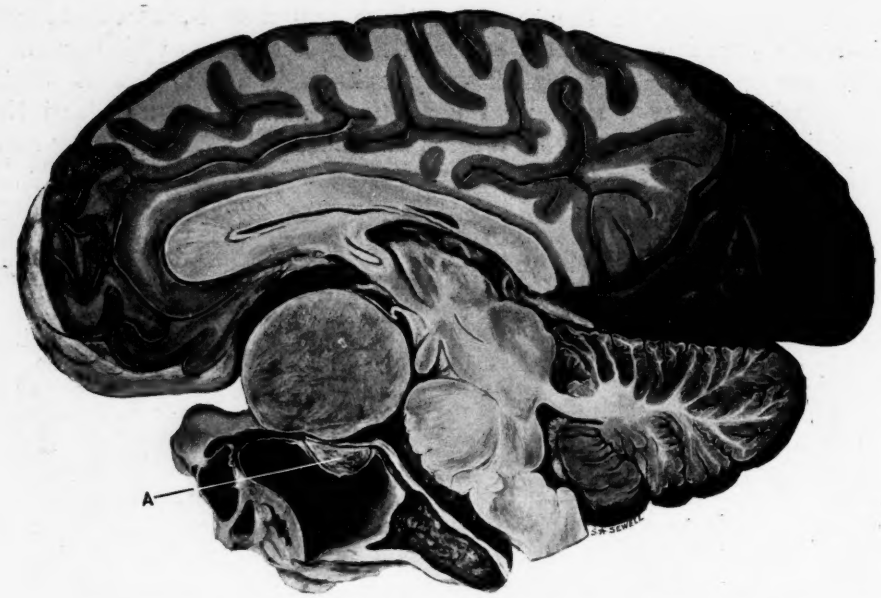


FIG. 306.—*Case* 1. Suprapituitary endothelioma. (*Specimen* 1452.2 *R.C.S. Museum.*) The patient was a man, 41 years of age, who had been under observation for eleven years for failing vision. He became completely blind in the left eye in about three months, and in the right eye in about ten years, after the onset of symptoms. No other symptoms, local or glandular, were observed until the onset of the general pressure symptoms some three months before death. The chiasma and optic nerves were stretched over the tumour, which was spherical and 3·2 cm. in diameter. It was only loosely connected with the membranes. A, Pituitary gland.

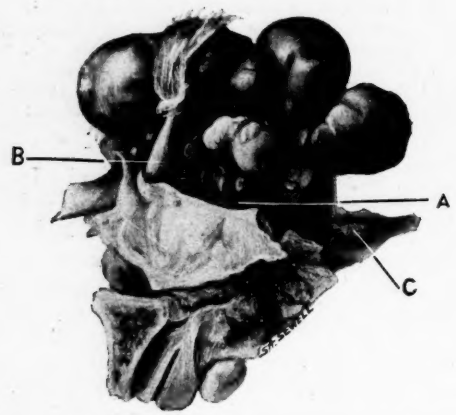


FIG. 307.—*Specimen* 1735.1, *R.C.S. Museum.* Left lateral view of a lobulated carcinoma from a man 35 years of age (Sir Charles Ballance's case), with a history of loss of vision and persistent headache for a period of five months. The right eye was quite blind, and the temporal field of the left was lost. No definite glandular symptoms were observed. A, Left 3rd nerve. B, Left optic nerve. C, Right 5th nerve.

by-product of such operations as are rendered justifiable by threatened blindness and intolerable headache. In the present state of our knowledge the surgery of the pituitary must concern itself primarily with the relief of pressure symptoms caused by tumours or other diseased conditions accompanied

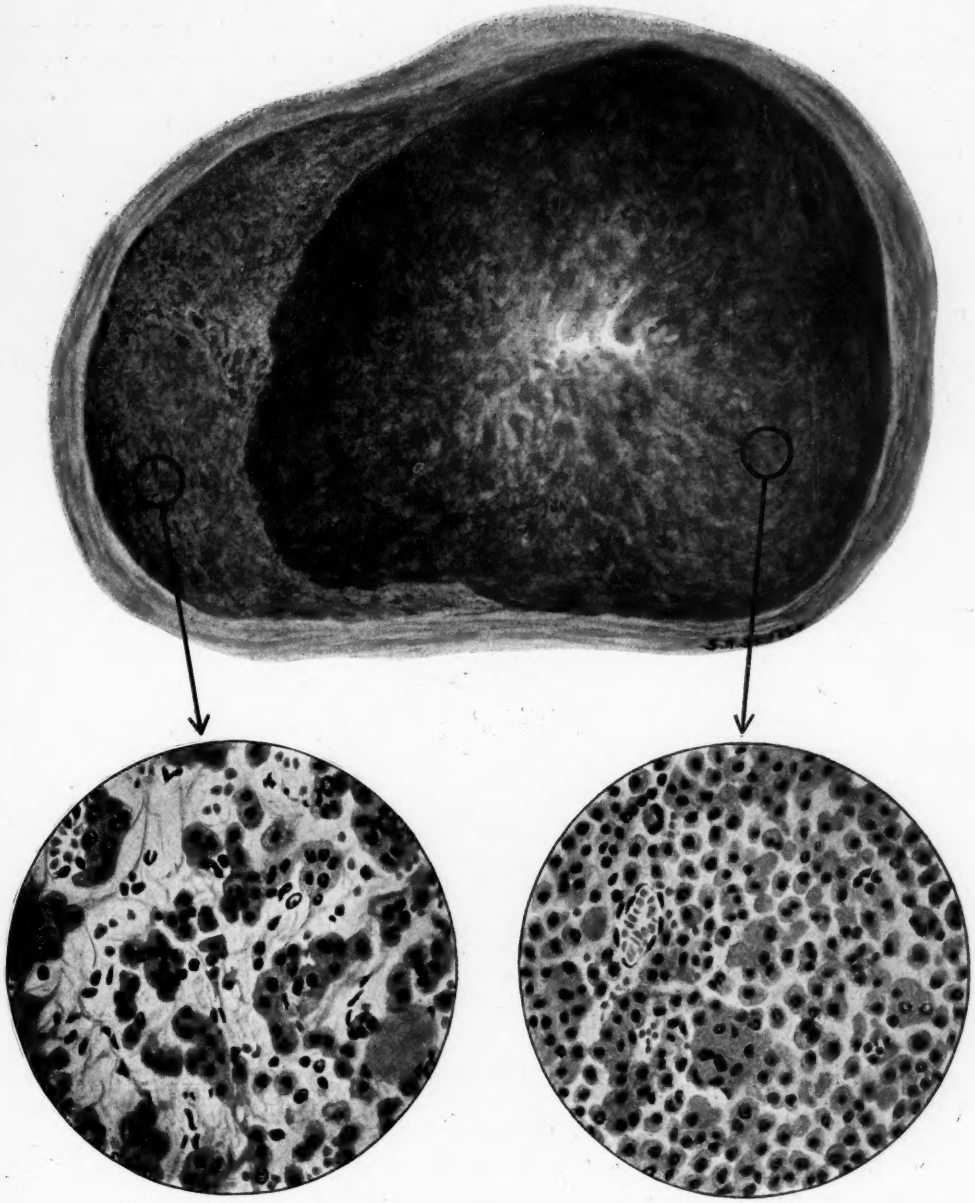


FIG. 308.—A minute intrapituitary adenoma.

A, Coronal section through the whole gland (× 10). The gland measured 15 × 10 × 10 mm. Shows adenoma replacing substance of pars anterior, a small crescent of which is seen to the left. The whole mass is intrasellar and surrounded by the dural capsule.

B, Section of normal part of gland (× 500) showing both oxyphil and basophil cells, and extreme vascularity.

C, Section of the adenoma (× 500). The cells resemble in type the oxyphil cells of the normal gland, but take the eosin stain less intensely.

by enlargement of the gland, and I intend here to confine myself to a brief inquiry based upon my personal experience.

Symptoms of pressure caused by pituitary enlargements are conveniently grouped as local and general. Any increase in the general intracranial pressure is to be regarded as of serious import, because it indicates that the intracranial extension of the tumour is large enough to cause an obstructive hydrocephalus. It also adds greatly to the dangers and difficulties of a direct attack upon the enlarged gland. When such symptoms are present, and the pressure is not of so high a grade that a fatal termination is inevitable, a simple decompressive operation in the temporal region is capable of affording a considerable degree of relief. This, however, must be regarded merely as a palliative operation, as in any other case of irremovable intracranial tumour, but with this difference, that it cannot be expected to relieve the headache which results from tension within the pituitary capsule, nor to benefit vision. It may also be employed as a preliminary measure to facilitate a subsequent frontal operation.

FIG. 369.—*Specimen* 48.1, *R.C.S. Museum.* From an acromegalic female, 41 years of age. The tumour, described as " histologically resembling the pars anterior of the normal gland ", measures 6·5 cm. in the vertical direction ; the intracranial portion has an antero-posterior diameter of 5 cm. (Reported by J. B. Neal and S. G. Shattock, *Trans. Pathol. Soc. Lond.*, 1898, xlix.)

It is in the relief of symptoms due to local pressure that most is to be expected from surgical intervention. I may say at once that, so far as my own experience goes, the term 'removal' used in connection with pituitary tumours has always meant 'partial removal'. I had until quite recently never encountered a case, or seen a specimen, in which total removal could by any possibility have been effected during life. (*See Figs.* 303 to 307.) The solitary possible exception is the case of a minute intrapituitary adenoma illustrated in *Fig.* 308. In this instance I had set out to remove part of the contents of the sella turcica, and had not a severe hæmorrhage unfortunately compelled me to abandon the operation, I should probably have succeeded in removing this tumour.

The two outstanding pressure symptoms which can be relieved by operation upon the enlarged gland, or upon tumours in its immediate vicinity, are

visual deterioration and headache, whether that headache be of the peculiar frontal, paroxysmal 'bursting' type which has been called 'pituitary headache', or of the more ordinary character dependent upon a general rise of intracranial pressure. It is my present opinion that progressive visual deterioration and severe headache are the only symptoms which justify a surgical attack upon a pituitary tumour. When an operation is being planned, it must be remembered that the size of the sella turcica as indicated radiographically gives no information as to the total size of the pituitary enlargement; and further that, by the time the visual symptoms are at all pronounced, the bulk of the tumour within the cranial cavity is usually greater than that portion which lies within the sella turcica (*Fig.* 309). The increased intracranial pressure which results from this extrasellar extension is a factor of supreme importance from the operative standpoint. This fact should be given due consideration when the methods of approach are being weighed.

During the past few years I have operated upon 38 patients for pituitary disease, actual or supposed. The number is too small to permit of any but the most tentative conclusions, and even those who indulge in the fallacious practice of expressing surgical results in mathematical terms would derive little satisfaction from so meagre a list. On the other hand, the number is not too large to prevent all the cases being briefly tabulated, and it is in this form that I have set forth the main facts concerning them.

ANALYSIS OF 38 CASES OPERATED UPON.

I. 17 Cases of 'Adenoma' or 'Hyperplasia of Pars Anterior'.

4 *Trans-sphenoidal Operations with Partial Removal.*—

Case 2.—M., 20. Considerable improvement (died of pneumonia 15 months later).
Case 3.—M., 21. Very great improvement in every way, especially visual. (Lost trace of after 6 months owing to war. Patient was a German clerk.)
Case 11.—M., 25. Temporary improvement in headache and vision. Relapse a few months later. Temporal decompression followed by improvement.
Case 14.—M., 38.—Died of meningitis.

9 *Frontal Operations with Partial Removal.*—

Case 8.—M., 35. Died within a few hours.
Case 18.—M., 34. Died within 24 hours.
Case 20.—F., 48. Very great improvement. Well 2 years later.
Case 21.—M., 21. Very great improvement. Well 2 years later.
Case 24.—M., 30. Died within a few hours.
Case 25.—M., 40. Excellent recovery. Died of pneumonia 4 months later.
Case 26.—M., 35. Died of pneumonia a week later.
Case 27.—F., 50. Died next day.
Case 38.—F., 48. Excellent recovery. Recent case.

3 *Frontal Operations without any Removal of Tumour.*—

Case 5.—M., 23. Fatal hæmorrhage from circle of Willis during operation.
Case 30.—M., 31. Abandoned as a simple decompression on account of general pressure. Good recovery.
Case 37.—F., 41. Fatal hæmorrhage during operation.

1 *Temporal Operation.*—

Case 22.—M., 40. Simple decompression. Improved in all respects and resumed work (clerk).

II. 11 Cases of Suprapituitary Tumour (Endothelioma 5, Cholesterin cyst 3, Infundibular tumour 3).

a. 5 *Endotheliomata.*—

Case 1.—M., 41. Bitemporal decompression when *in extremis*. Died.
Case 6.—M., 30. Frontal operation—partial removal—excellent recovery. Lost trace of owing to war (German musician).
Case 16.—M., 42. Temporal decompression—improved. Survived 3 years.
Case 31.—F., 49. Frontal operation—partial removal—excellent recovery. Well 11 months later.
Case 32.—F., 42. Frontal operation—partial removal—excellent recovery. Well 6 months later.

b. 3 *Infundibular Tumours.*—

Case 7.—F., 25. Frontal operation—partial removal. Died 10 days later. (Ganglio-neuroma.)
Case 10.—F., 35. Temporal decompression. Died soon after operation. (Ependymal tumour.)
Case 23.—M., 10. Temporal decompression followed later by frontal exploration. Died soon after operation. (Ependymal tumour.)

c. 3 *Cholesterin Cysts.*—

Case 15.—F., 18. Frontal operation—evacuation. Died 12 days later. (Maniacal.)
Case 19.—M., 54. Temporal operation—evacuation. Died 2 months later.
Case 28.—M., 39. Temporal operation—evacuation. Died 3 years later. (Insane.)

III. 4 Cases of 'Cystic Serous Meningitis'.

Case 12.—M., 49. Frontal operation. Three years later quite well. Vision better.
Case 13.—F., 36. Frontal operation. Much improved. Died 3 years later (? cause).
Case 17.—M., 36. Temporal operation. Improved. Alive 3 years later.
Case 36.—F., 31. Frontal operation. Back to work. Well 6 months later.

IV. 6 Cases Wrongly Diagnosed.

Case 29.—F., 36. *Frontal endothelioma.* Frontal exploration. No improvement. Died 2 months later.
Case 34.—M., 31. *Frontal glioma.* Nasal operation. Died in coma a week later.
Case 35.—F., 13. *Frontal glioma* compressing pituitary. Temporal decompression. Relief. Died 10 months later.
Case 33.—F., 12. *Mesencephalic glioma; hydrocephalus.* Nasal operation. Died of meningitis.
Case 4.—M., 53. *Arteriosclerosis; optic atrophy.* Frontal exploration. Died 6 years later. Post mortem, no other lesion.
Case 9.—M., 27. *No gross lesion.* Frontal exploration. Atrophied optic nerve. Alive 5 years later—periodic headaches.

If so far the tale is a disheartening one, we have to remember that many of the failures can be traced to causes which subsequent experience has shown to be preventable, and that a much larger proportion of good results can be confidently expected when we have learnt to minimize mistakes of diagnosis, judgement, and technique. Even such simple operations as prostatectomy have passed through a period of excessive mortality. We must remember, too, that many of these patients suffer from a number of distressing symptoms which often render life insupportable, and from a disease which, after causing complete blindness, will ultimately prove fatal, so that even a few strikingly good results, although they may concern but a small proportion of the whole, are not to be despised. I feel confident that with better

judgement in the selection of cases, with increasingly improved operative technique, and above all, perhaps, by operating at a much earlier stage in the evolution of the disease, it will be possible to benefit a far larger percentage of these unfortunate patients. In this connection the following case (*Case* 37) is of special interest. It shows that with intrasellar growths it may be possible to make the diagnosis when the tumour is still small and confined within the sella, before any conspicuous enlargement of the sella has occurred, and before the general intracranial pressure is raised. It also shows that considerable restriction of the visual fields may occur from very slight upward bulging of the diaphragma sellæ. Had it not been for an unfortunate operative accident, there is every reason to believe that the little tumour would have been removed completely, and that the result as regards headache and vision, and perhaps also as regards the glandular symptoms, would have been good.

Case 37.—The patient, a female, 41 years of age, had suffered for ten years from severe headaches, and had noticed her hands getting larger. Disturbance of vision was first noticed about six months before her admission to hospital. For some years the headaches had been related to the menstrual periods, and had been chiefly frontal. The hands and feet had gradually enlarged, and the facial appearance had altered. On admission, the visual fields were found to be greatly diminished concentrically, that for green being the smallest and that for the white the largest, the red field being intermediate in size. The optic discs were normal. X-ray examination showed no enlargement of the sella. No operation was advised, and she left the hospital. She was re-admitted four months later, the headache having become intolerable, and now frequently accompanied by vomiting. The visual fields had become much smaller concentrically, and still showed no quadrantic or hemianopic defect. The optic discs were slightly paler than normal. A trace of sugar had appeared in the urine.

A frontal osteoplastic exploration was carried out, and the pituitary region inspected. There appeared to be no bulging from the fossa. The diaphragma sellæ was incised, so as to relieve tension. Recovery was uneventful, and the headache was completely relieved. Headache began again after six weeks' complete freedom, and the patient returned to hospital six months after operation. The headache had again become extremely severe, but visual acuity had improved to $\frac{6}{6}$, and the fields were a good deal larger. The discs appeared normal, and there was no glycosuria. It was determined to remove part of the contents of the sella turcica, and the region was again exposed through the osteoplastic opening. Unfortunately hæmorrhage, from a source which could not afterwards be traced, necessitated abandoning the operation. Death occurred within a few hours.

Post mortem, the pituitary gland was removed, and found to be scarcely if at all enlarged. It contained a minute adenoma (*Fig.* 308).

Selection of Cases.—If we are to avoid operating upon unsuitable cases we must in the first instance seek to improve our diagnosis. Many conditions cause symptoms which may be reasonably yet wrongly ascribed to pituitary lesions. No fewer than 6 of my 38 cases belong to this class; three were cases of tumour of the frontal lobe causing visual deterioration from pressure upon the optic nerve, or chiasma, with disturbance of function from pressure upon the pituitary gland; one was a mesencephalic glioma which gave no localizing signs, but which by causing ventricular distention produced enlargement of the sella and symptoms of hypopituitarism; two were cases of optic atrophy without gross lesion, in which the operation was of a purely exploratory character. They illustrate some of the difficulties of diagnosis, and the cases

in which no gross lesion was found are also interesting as demonstrating with what ease and safety the infundibular region can be explored by the frontal route.

In a large proportion of cases, however, the diagnosis of pituitary tumour can be made with precision and at an early stage; but unfortunately the nature and extent of the lesion cannot always be accurately diagnosed. At present, therefore, many of our operations must necessarily be of an exploratory character. Even when exposed, the full extent of the tumour can rarely be ascertained accurately. In several cases in which I was able to remove a considerable quantity of tumour tissue, subsequent post-mortem examination showed that the extent of the growth was such as to defeat any surgical attack upon it. In some such cases, had an accurate diagnosis of its extent been possible beforehand, I should have realized that a simple decompressive operation was the only possible surgical procedure. Even in cases of simple pituitary adenoma, with great enlargement of the sella, the diagnosis of which is usually easy, it is impossible to estimate the extent of the intracranial portion of the tumour.

Causes of Failure.—Operations for pituitary tumour are so hedged about with dangers and difficulties that the patient who successfully runs the gauntlet may indeed be accounted fortunate. Quite apart from the local difficulties which may be encountered, the general physical condition of the patients is usually such that they support very badly surgical procedures of any magnitude, whilst they seem to be conspicuously lacking in resistance to infection, and are therefore liable to succumb to pneumonia.

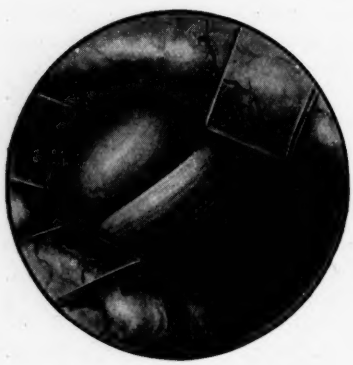


FIG. 310.—*Case* 28. From a sketch made during operation. Shows a large suprapituitary cholesterin cyst exposed by the temporal route, with the optic nerve stretched over it, and displaced downwards and forwards.

Further, it is unfortunately true that by the time the patient is submitted to operation the general intracranial pressure is often so great that the physical difficulty of approaching the pituitary region may be insurmountable, even with the assistance of a previous decompressive operation, or of lumbar or ventricular puncture. The degree of this increased intracranial pressure is more difficult to estimate beforehand than in the case of tumours elsewhere in the brain, because, owing to the direct pressure upon the optic nerves, we are denied the information which in other cases we derive from measuring the degree of papillœdema.

There is yet another source of failure which I have observed, and which I believe to be of great importance, and it is perhaps in some measure comparable to one of the causes of death after operation for exophthalmic goitre. The escape of toxic material from the tumour into the cerebrospinal fluid, both during and after operation, seems to be capable of producing grave and even fatal symptoms. This, I think, is especially true in the case of cysts containing cholesterin. I now seek to avoid this complication in two ways: first, by removing the contents of the tumour capsule by aspiration; and

secondly, by sealing the opening in the capsule with a muscle-graft before completing the operation.

The causes of failure, then, so far as my own experience teaches, may be summed up as follows: (1) Errors of diagnosis leading to misdirected operations; (2) Massive intracranial extension of the tumour, rendering the case unsuitable for any operation except a palliative decompression; (3) Operative accident; (4) Post-operative pituitary toxæmia; (5) Post-operative pneumonia; (6) In trans-sphenoidal operations, septic infection.

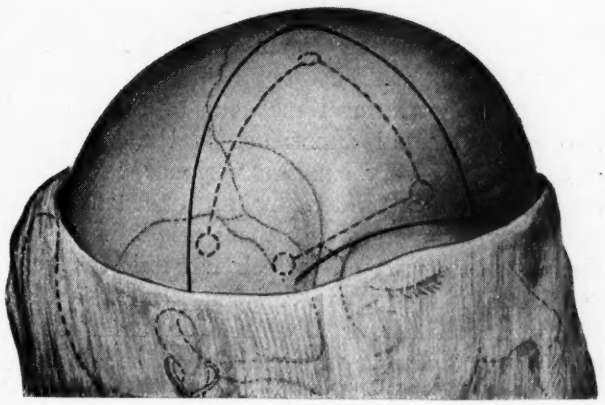


FIG. 311.—Outlines of osteoplastic flap for frontal approach (modified Frazier operation).

Methods of Approach.—The many methods of surgical attack which have from time to time been devised may be regarded as falling into two groups: the *extradural*, embracing transpalatal, nasal, and paranasal operations; and the *intradural*, comprising the temporal and frontal. Horsley, who in 1906 had already operated upon nine cases, strongly favoured the temporal route. At that date he wrote, in characteristic fashion, "The prehistoric way of raising the frontal lobe is not the proper way to remove the tumour; it should be done by raising the temporal lobe."[2] The records of the National Hospital, Queen Square, include only four cases operated upon by Horsley between the years 1902 and 1911; one patient died shortly after the operation, one lived nine months, another three years, and another eight years. In two of them some degree of ophthalmoplegia followed the operation, and in two others some aphasia and hemiparesis. It is clear that in elevating the temporal lobe there is more risk of damaging important areas of the brain than in elevating the frontal lobe. The temporal route, however, may sometimes be the method of choice, particularly when the chief object aimed at is a general decompressive effect (*Fig.* 310).

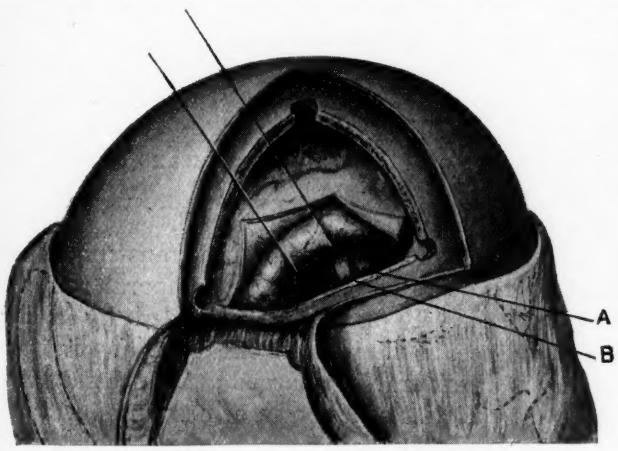


FIG. 312.—Exposure of tumour by frontal osteoplastic approach. A, Tumour; B, Optic nerve and ophthalmic artery.

The intradural route which I have found to give a perfectly satisfactory approach to the sella turcica is a modification of the osteoplastic orbito-frontal method of Frazier. The only real difference between this and the original Frazier operation is that I make a much larger osteoplastic flap, so as to render interference with the orbit and supra-orbital ridge unnecessary. Even in the thick and bossy acromegalic skull I find no difficulty in reaching the interpenduncular space without removing the supra-orbital ridge. (*Figs.* 311, 312).

Of the extradural methods of approach, the only one of which I have had any personal experience is the trans-sphenoidal operation of Cushing, and this is a very small experience, including but six cases. Although one of these was attended by an excellent immediate result, particularly as regards vision, and two others might be regarded as satisfactory results, yet I cannot bring myself to feel that it is the best method. Its chief attractions are that it is a comparatively easy operation, and is one which patients of poor stamina, as these usually are, can easily support; further, the likelihood of causing the pituitary toxæmia to which I have referred is almost if not completely abolished. But it is not free from the dangers of septic infection, and as so little can be accomplished through so small an opening, the beneficial effects are likely to be meagre and transient. It is, moreover, only applicable to cases of pituitary tumour in which the sella turcica is conspicuously enlarged; no information can be gained as to the extent of the intracranial extension, and no general decompressive effect can be obtained. The frontal operation, on the other hand, allows of thorough exploration, of partial removal of the intracranial extension, of dealing with suprapituitary tumours and other lesions in the neighbourhood, and of some measure at least of general decompression, whilst it is free from the dangers of septic infection.

SUMMARY.

Operations for pituitary tumour are only justified as a means of relieving headache or averting blindness.

Tumours are rarely, if ever, capable of complete removal.

The choice of operative approach lies between the trans-sphenoidal method of Cushing, the frontal route of Frazier, and the temporal route of Horsley. The first-named is comparatively easy and attended by a low mortality-rate, but its field of usefulness is limited to one type of pituitary tumour in which the sella turcica is considerably enlarged; the second gives better access, and can be used for all varieties of lesion in or near the pituitary gland; the third is useful for cases in which the general intracranial pressure is high.

REFERENCES.

[1] CUSHING, *The Pituitary Body and its Disorders*, 1912.
[2] HORSLEY, *Brit. Med. Jour.*, 1906, Feb. 10.

TRANSPLANTATION OF THE TENSOR FASCIÆ FEMORIS IN CASES OF PARALYSIS OF THE QUADRICEPS MUSCLE.

By NAUGHTON DUNN and F. WILSON STUART, Birmingham.

In the upper extremity the action of individual muscles is highly specialized. In this case re-education allows us to utilize individual muscles effectively when dissociated by transplantation from the group with which they are normally in action.

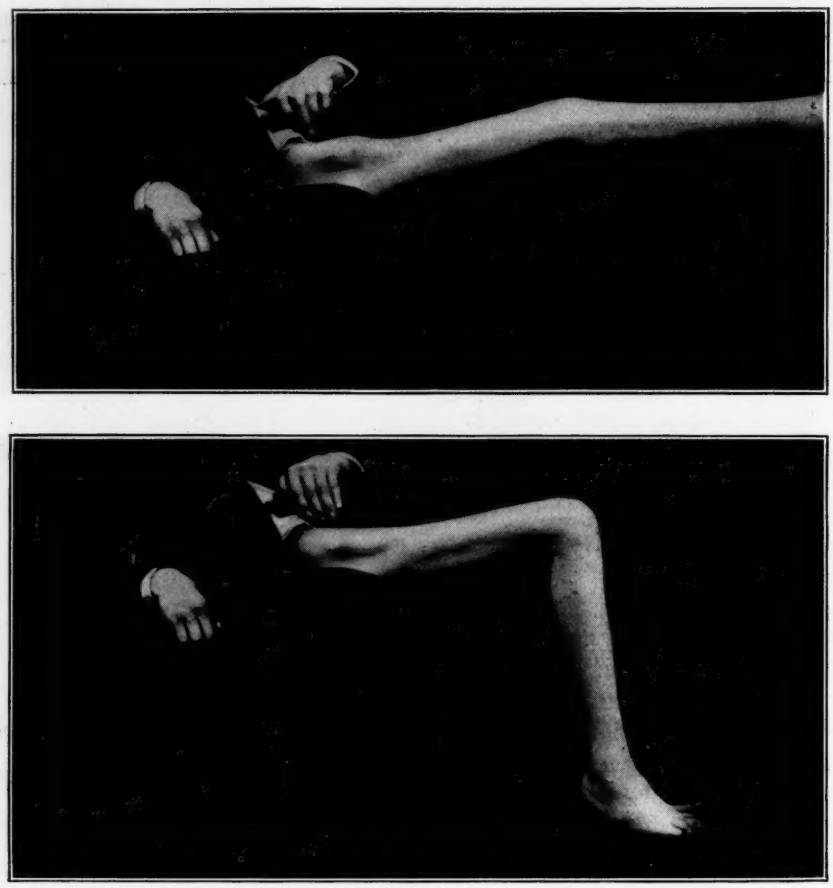
In the lower extremity the movements of the joints in propulsion of the body are automatic, and are controlled by strong muscle groups. It is therefore difficult to re-educate an individual muscle to act apart from the group with which it is normally in action. This, we believe, explains the failure of the peroneus longus to replace a paralysed tibialis anticus, and of the transplanted biceps tendon effectively to replace a paralysed quadriceps.

A safe clinical test in the selection of tendons for successful transplantation in the lower extremity is that the muscles transplanted should be those used by the patient in his effort to replace the action of the paralysed muscle. In an appreciable number of cases of infantile paralysis, power of extending the knee-joint is lost, while definite power is present in the sartorius and (or) the tensor fasciæ femoris. If such a patient is asked to extend his knee-joint, one or both of these muscles will tighten, and the external or internal rotation of the limb will depend on the relative power in these. Both will make an effort to replace the action of the quadriceps. By altering their insertion to the patella their effort becomes effective.

Attention has already been drawn to the results of transplantation of the sartorius where this muscle is active in the presence of quadriceps paralysis. We now wish to record two cases in which the tensor fasciæ femoris has been successfully utilized by transplantation as an effective extensor of the knee-joint.

Operation.—A skin incision is made from the anterior superior iliac spine along the outer aspect of the thigh to just below the knee-joint, where it curves across the limb. Flaps are raised on either side, the anterior one sufficiently to allow exposure of the patella. The anterior and posterior borders of the tensor fasciæ femoris and the iliotibial band throughout its length are exposed. The anterior and posterior borders of the tensor fasciæ femoris are defined. From these borders two incisions extend downwards to the knee-joint, giving a breadth of fascia lata equal to the breadth of the muscle at its insertion. This long ribbon of fascia and muscle is freed and transplanted to the quadriceps tendon and the patella. The points to which special importance is attached are that its course from origin to insertion should be a direct one, and that it should be safely sutured under tension.

The after-treatment is also important. No strain should be put on the new insertion for six weeks. A caliper splint is worn until electrical treatment and re-education of the transplanted muscle have developed it sufficiently to maintain extension of the limb.



FIGS 313, 314.—Showing hypertrophy of tensor fasciæ femoris and its action as an extensor of the knee-joint after its transplantation to the patella.

In both the cases reported the transplanted muscle has hypertrophied, and active extension of the knee-joint by it is now possible.

THE REMOTE RESULTS OF OPERATIONS FOR INJURIES OF THE PERIPHERAL NERVES.*

By HARRY PLATT, Manchester, and W. ROWLEY BRISTOW, London.

SUMMARY.

Introduction.

Pathological Considerations.

1. The pathogenesis of nerve injuries.
2. The distant effects of a nerve injury.
3. Associated lesions.

Principles of Operative Technique.

1. Difficulties in effecting repair.
2. Technique of nerve suture.

Clinical Considerations.

Results of Operations for the Repair of Nerve Injuries.

I.—Methods of estimation.
II.—Operations for the restoration of conduction.
1. Statistics.
2. Results of end-to-end suture.
3. Results of neurolysis.
4. Bridge operations.
III.—Operations for the relief of pain and other irritative phenomena.
IV.—Operations designed to restore function in irreparable lesions or in cases of incomplete recovery.

Summary.

Bibliography and References.

INTRODUCTION.

It is inevitable at this date that an inquiry into the remote results of operations for injuries of peripheral nerve-trunks should be dominated almost exclusively by the experience acquired in recent years in connection with the reconstructive surgery of the great war. From the unprecedented amount of material which has been under observation during this period much information has been gleaned, and the knowledge thus obtained has been widely disseminated. A most extensive literature has now accumulated around the subject, but it must be admitted—in this country, at least—that few statistics dealing with true end-results on a large scale have been forthcoming. For a considerable time, surgeons interested in this problem had the advantage

* This paper represents the British Report on this subject presented at the meeting of the International Association of Surgery in London on July 19, 1923.

of retaining in special hospitals large numbers of patients who were suffering from gunshot injuries of nerves. These patients have now been scattered far and wide, and many are no longer undergoing active treatment or rarely come under expert observation. During the past two years it has become increasingly difficult to add to those records already in our possession, which so far have illustrated little more than interim results.

The traumatic lesions of nerves which occur in civil life, and more particularly the type of injury in which end-to-end suture is demanded, do not ordinarily fall into the hands of individual surgeons in great numbers. Since the appearance of the monograph of Sherren in 1908, nothing has been added to the broad principles there formulated in regard to the results to be obtained after suture operations. But the past decade has seen a definite expansion and crystallization of our knowledge concerning the exact pathogenesis and the results of the surgical treatment of certain familiar nerve lesions belonging to the 'compression' class. These are: (1) The traumatic neuritis affecting the lower trunks of the *brachial plexus*, induced by a supernumerary cervical rib, or under certain conditions by a normal first dorsal rib; and (2) Traumatic neuritis of the *ulnar nerve* in the region of the elbow, developing after a latent period as the result of a fracture of the external condyle of the humerus in early life—the so-called 'late involvement' of this nerve. A detailed consideration of these special types of nerve injury does not concern us here. The surgical treatment of such lesions, however, illustrates very clearly the rationale of those operative procedures which are classed under the heading of *neurolysis*. In discussing the results of neurolysis in the case of gunshot lesions, passing reference will be made to these civil compression lesions for the purpose of comparison only. The report to be presented by the writers will thus deal with the results of operations performed for gunshot injuries alone.*

Before proceeding to introduce this subject in its more limited sense, it is advisable to review briefly certain fundamental considerations which have an essential bearing on the study of the various factors which may determine the success or failure of any form of operative repair.

PATHOLOGICAL CONSIDERATIONS.

1. The Pathogenesis of Nerve Injuries.—The characteristic pathological anatomy of the nerve lesions of warfare is now so widely known that it is unnecessary to do more than stress certain outstanding features.

In the vast majority of instances the nerve injury belongs to the 'primary' class, and gross destruction with immediate loss of anatomical continuity is frequently seen. To the primary destructive effect of the missile is added the influence of a second potent factor—wound infection. Further destruction of nerve tissue now takes place in the course of the acute inflammatory reaction which follows. With the onset of the phase of healing and the

* The authors have reviewed all the available literature on this subject published in the various countries during recent years, and the information thus derived is embodied in their general criticisms and conclusions. The statistics reproduced, however, have been deliberately limited to those issued from the various British surgical centres.

production of young scar tissue, there is seen a still further obliteration of nerve substance. Finally, the scar tissue when fully matured has built up an impenetrable barrier which effectively prevents the growing axon of the proximal stump from obtaining access to the distal stump. These are the grosser mechanical results of wound infection. But the nerve sustains a more insidious type of damage during the time that it lies bathed in the inflammatory exudates. Bacteria and their toxins pass into the interior of the nerve-trunk, and ascend for some distance above the limits of the initial lesion. The result is the development of an interstitial neuritis, the final histological picture showing a fibrosis involving the connective-tissue framework between the nerve bundles and around the individual nerve-fibres. Ascending neuritis of this type has been traced in injured nerves for many inches above the original lesion, and there is evidence to suggest that this process may occasionally reach the spinal roots. In the type of nerve injury in which there is little or no anatomical loss of substance, intraneural fibrosis in the proximal part of the nerve is often a dominating feature of the lesion. It is a well-established fact that an extensive interstitial neuritis exerts an inhibitory influence on the regenerative process; and further, if regeneration occurs, the symptoms of severe irritation may appear during the early stages of sensory recovery.

The fully-matured lesion as seen during an exploratory operation represents a composite histological picture, to which the primary injury, the effects of wound infection, and the attempts at spontaneous repair on the part of the nerve have all contributed. A classification of lesions based on operation records alone can therefore have no exact anatomical or pathological basis. At the same time, a recognition of certain standard naked-eye appearances is useful for descriptive purposes. Broadly, we may recognize three main types: (1) Complete division with a gap; (2) Complete division without a gap—in this form the nerve-trunk retains a pseudo-continuity; (3) The nerve-trunk is apparently intact, but presents a wide variety of local alterations in contour, size, and consistence. A familiar example is the nerve 'spindle' or fusiform 'neuroma'.

2. **The Distant Effects of a Nerve Injury.**—

a. Central Changes.—The significance of those early retrogressive changes which take place in the central spinal cells when the continuity of the axis cylinders is interrupted should not be overlooked. These changes are known to be most marked when the nerve injury is extensive, and particularly when the lesion is situated high up on the proximal course of the nerve. It is generally believed that the long-continued existence of a peripheral block to regeneration is always associated with the production of permanent degenerative changes in the controlling nerve-cells. This is one factor which, in combination with others, may help to determine the imperfect results seen in nerve sutures performed after long periods of delay. But the reparative capacity inherent in these cells would appear to be highly developed, for, in cases of resection and *resuture* performed as long as three years after the failure of a preliminary suture, recovery of the average type and degree has been seen (Stopford[1]).

b. Peripheral Changes.—The changes affecting the tissues to which the

ultimate nerve-fibrils are distributed are of two types: (i) Simple *disuse atrophy* such as is seen best of all in the muscle bellies, and which is the direct result of the severance of axis cylinders (denervation); and (ii) *Trophic* changes proper, which are dependent always on the existence of some form of irritation acting on vasomotor and sensory axons which still retain their integrity. The effects of irritation are exhibited in the evolution of a widespread fibrosis in the intramuscular connective-tissue planes and in the tendon sheaths and joint capsules—a familiar morbid picture in many of the gunshot injuries of nerves, and generally best marked in the hand. The intensity of these fibrotic changes is accentuated where gross infection has been present. It is to be remembered that similar fibrotic changes may follow obliteration of the main vessel of a limb even in the absence of a nerve injury (ischæmia). In long-standing nerve injuries, even where the influence of infection has been negligible and where irritative signs have been conspicuously absent, a certain degree of interstitial fibrosis in the denervated muscles may be seen. But under such conditions these muscles retain for long periods an anatomical structure which after re-innervation is not incompatible with function.

3. **Associated Lesions.**—In gunshot wounds of the limbs a nerve lesion often forms but one component of a complex injury in which there is an extensive destruction both of bone and soft parts. Here, again, the secondary effects of wound infection are to be reckoned with, for fibrotic changes develop in a quiet fashion in tendon sheaths and joint capsules in regions remote from the point of injury, owing to the transference of infection by a process of metastasis. Such changes attain their maximum intensity in the tissues of the hands and feet. The disability resulting from the nerve lesion *per se* is thus often overshadowed by the changes produced by the co-existing lesions. Such complications offer grave mechanical obstacles to the attainment of effective operative repair of the nerve injury. Moreover, where the latter procedure is followed by success in a neurological sense, very little may be added to the functional value of the limb.

PRINCIPLES OF OPERATIVE TECHNIQUE.

1. **Difficulties in Effecting Repair.**—The earlier phases of the peripheral nerve surgery of the war were to a large extent experimental, but operative methods soon became stabilized. The mechanical difficulties experienced in obtaining end-to-end apposition of the proximal and distal stumps in the case of the more extensive lesions brought into prominence for a time the question of the value of the methods of indirect repair—e.g., nerve-grafting, tubulization, etc.—procedures conveniently termed 'bridge' operations. In this country an unbiased study of the results of the operations falling into this category soon showed that there was no justification for their continued inclusion in the repertoire of peripheral nerve surgery. With increasing experience the number of lesions found to be irreparable by the method of direct repair steadily diminished. The difficulties encountered were surmounted in the vast majority of cases by a recourse to one or more of the following technical manœuvres, which to-day may be regarded as standardized procedures:—

a. The widest anatomical exposure with the freest mobilization of the proximal and distal parts of the nerve-trunk.

b. The additional relaxation of the nerve afforded by appropriate *alterations in the posture* of the limb, e.g., bringing the limb into close contact with the body, with full flexion of certain joints.

c. The stripping up of motor branches arising proximal to the lesion, from within the nerve sheath; or, where absolutely necessary, the deliberate sacrifice of one or more branches.

d. The displacement of the nerve to a new bed in such a manner as to shorten its course, e.g., anterior displacement of the ulnar at the elbow, or transference of the musculospiral to the front of the upper arm (Stiles).

e. The two-stage operation, in which, after the fullest exposure and relaxation of the nerve, the central and distal stumps—untrimmed—were drawn close together by means of stout sutures and the wound then closed. Gradual stretching of the flexed joint was begun at an early date, and at the end of a fortnight or three weeks the wound was re-explored and an attempt made to complete the suture. In such cases the gap originally present was found to have diminished considerably owing to the steady traction which had been exerted on the anchored ends.

f. Bone shortening. This was practised in cases of co-existing ununited fractures where considerable trimming of the bone-ends was a necessary part of an operation to obtain union—e.g., in extensive musculospiral nerve lesions combined with persistent non-union of the humerus—but only very rarely under any other circumstances.

2. **Technique of Nerve Suture.**—For lesions in which end-to-end suture was indicated—whether after resection of a length of nerve or after approximation of the stumps of a nerve already divided—it was found essential to trim the ends on a generous scale in an attempt to get above the level of the grosser intraneural fibrosis. In many cases this brought the lesion perilously near the irreparable class. Resection a little short of the ideal level matters less perhaps in a nerve which contains a preponderance of motor fibres, e.g., the musculospiral, than in the case of the median or sciatic nerves with their profusion of sensory and sympathetic axons. At the line of suture the nerve-ends should be in bare contact under slight tension, without any crowding together or eversion of the fasciculi. Experience has shown that sheath sutures alone are desirable, and that a stay suture passed through the whole thickness of the nerve-trunk is best avoided. The suture material should be of the finest calibre compatible with the strain to which it is subjected. In the experimental work of Sargent and Greenfield[2] it has been conclusively shown that the finest linen thread (No. 160 as introduced by Stiles) is the ideal material. Catgut impregnated with chemical irritants has no place as a suture material for a divided nerve.

The protection of the line of suture by sleeves of fat, fascia, or prepared animal membranes was soon given up. Whenever possible, the nerve should be placed in a bed consisting of healthy muscle tissue. In certain regions where this is not possible, a small sheet of fascia inserted under the nerve forms the most efficient protection from denuded bone, rough callus, or bare tendons.

CLINICAL CONSIDERATIONS.

Many of the older statistics dealing with the results of operations for the repair of nerve injuries must now be regarded as unreliable in the light of our present-day knowledge of the difficulty experienced in recognizing the signs of genuine recovery. Many pitfalls beset the path of the clinical observer. On the motor side there are the now well-recognized 'trick' or substitute movements which have been studied and reported in full detail by Wood Jones.[3] From his account may be quoted the following examples :—

1. With complete division of the *median* and *ulnar* nerves in the upper arm, flexion of the wrist may be carried out by the action of the extensor ossis metacarpi pollicis.

2. With complete division of the *musculocutaneous* and *musculospiral* nerves in the axilla, flexion of the elbow is carried out by the combined action of the pronator radii teres and the common flexors of the wrist and fingers.

3. With complete division of the *median* and *ulnar* nerves in the upper arm, flexion of the fingers is carried out by voluntary dorsiflexion of the wrist, the paralysed tendons acting as ligaments and thus approximating the fingers to the palm.

4. With complete division of the *median nerve* in the forearm, opposition of the thumb may be carried out by the combined action of the adductores pollicis (ulnar) and the extensor ossis metacarpi pollicis (musculospiral).

These and similar trick movements are often carried out quite forcibly and against the action of gravity. They have been found to vary greatly in different individuals, and were not acquired by the majority of patients with nerve injuries.

On the sensory side, the variations which may occur in the loss of sensibility, particularly as estimated by the appreciation of the pain of pinprick —'protopathic' sensation—are now better recognized. As an example, the variations which are met with after division of the median nerve may be quoted. The area of loss to pain generally embraces the palmar surface of the thumb, index, and middle fingers and the adjoining third of the palm ; but in certain individuals the area of overlap of the ulnar nerve for this form of sensation is unusually extensive. Complete division of the median in the forearm may then result in loss to pinprick over the palmar aspect of the terminal phalanx of the index and medius alone. Unless the observer recognizes these facts, he will regard the appreciation of painful stimuli on this area as evidence of recovery, or incomplete division of the nerve. Such fallacies in interpretation explain the cases of preternaturally early recovery after nerve suture which from time to time are recorded in surgical literature, and also many of the reported successes of nerve-grafting operations.

I. RESULTS OF OPERATIONS FOR THE REPAIR OF NERVE INJURIES:—

METHODS OF ESTIMATION.

In judging the late results of operations for the repair of peripheral nerve injuries, it is necessary to make a clear distinction between two standards of assessment, the physiological or neurological, and the functional or economic.

The former simply represents the amount of conductivity which has been restored to the nerve as measured by clinical and electrical tests. The latter, as the term would indicate, denotes the degree of general utility which the limb or part exhibits, apparently as the result of the operation. The two standards do not necessarily run on parallel lines. A good functional result may be seen in the presence of a poor neurological result; and, on the other hand, with a satisfactory or wellnigh perfect neurological result, there may be little improvement in the functional capacity of the limb. The reasons for such discrepancies are not far to seek. It is to be recalled that the effects of a complete lesion of a peripheral nerve may constitute little practical disablement in certain individuals. Thus, the elimination of the function of the intrinsic muscles of the hand in injuries of the *ulnar nerve* is of paramount importance only to those whose occupation demands the finer hand movements. One of the writers recently had the opportunity of examining a bricklayer under treatment for a wound of the leg who had sustained a complete division of the ulnar nerve at the wrist nineteen years before. He stated that his capacity for work had not been lessened by the wasting or loss of sensation in the hand. In lesions of the *median nerve*, the anæsthesia of the index finger is a far more serious disability, and impairs the capacity of the hand for most types of work.

Again, the loss of conduction and function due to a nerve injury may be overshadowed by the disabling effects of the consecutive or co-existing changes in other tissues. As already stated, the successful repair of the nerve, even if restoration of conduction and function go hand in hand, may then be of no practical value to the patient. Finally, in the absence of mechanical obstacles to the restoration of function, delay may be dependent on psychical causes.

Most of the available records are based on a neurological standard alone. For reasons which are sufficiently obvious, a survey of the economic or industrial capacity of large numbers of war-disabled men would to-day be an impossible task.

The operations which have been practised may be grouped conveniently into three classes: (1) *Operations for the restoration of conduction* (direct and indirect nerve repair); (2) *Operations for the relief of pain and other irritative phenomena*; (3) *Operations designed to restore function in irreparable lesions or in cases of incomplete recovery.*

II. RESULTS OF OPERATIONS FOR THE RESTORATION OF CONDUCTION.

Under this heading are included *end-to-end suture*, *neurolysis*, and the small group of operations best described by the term '*bridging*'.

1. STATISTICS.

When an attempt is made to correlate the results recorded by different observers, we find that it is safer to avoid the massing together of mere statistics. It is more logical simply to present those broad conclusions which a study of a few typical series of operation results affords us. Before entering upon the latter task, we may quote briefly from some of the larger individual series

of operations which have been published in this country during recent years. When compared with the number of operations actually performed in the various surgical centres, the published statistics are seen to be comparatively scanty. From such centres as the Special Surgical Hospitals at Shepherds Bush and Tooting (London), and the Royal Herbert Hospital, Woolwich—centres in which exceptionally large numbers of operations were conducted by a small group of experienced surgeons—we have no figures. Much of the information, however, which appeared in the *Report of the Peripheral Nerve Committee of the Medical Research Council* issued in 1920 was founded on experience gained in these and other centres where it has not been practicable to follow up the more remote results on a large scale.

Kennedy[4] (Glasgow) 1919 :—

25 operations on various nerves (civil injuries).

End-to-end suture—Complete success in 73 per cent ; incomplete success in 26 per cent.

Neurolysis—Complete success in 70 per cent ; incomplete success in 30 per cent.

Complete failures—None.

Stopford[5] (Manchester) 1920 :—

271 operations—gunshot injuries.

Operations performed by various surgeons. Type of operation—end-to-end suture. Standard of recovery—neurological.

A. Upper Limb (median, ulnar, and musculospiral nerves).

Upper arm—Recovery of varying types in 88 per cent ; failures (complete) in 12 per cent.

Forearm—Recovery in 76 per cent ; failures in 24 per cent.

B. Lower Limb (sciatic, external, and internal popliteal nerves). Recovery in 85 per cent ; failure in 15 per cent.

These figures are largely *interim* results.

Forrester-Brown[6] (Edinburgh) 1920 :—

475 operations—gunshot injuries.

Operations performed by Sir Harold Stiles and the recorder. Standard of recovery—neurological.

A. End-to-end suture—158 operations.

(1) All cases.

Complete motor recovery 29 per cent.

Complete sensory recovery 19 per cent.

Complete trophic recovery 21 per cent.

Incomplete recovery of all functions 50 per cent.

(Total complete recovery seen in *five median nerve* sutures and *eight musculospiral nerve* sutures.)

(2) Comparison between different nerves.

Median nerve—50 per cent complete motor recovery ; 28 per cent complete sensory recovery.

Ulnar nerve—17 per cent complete motor recovery ; 13 per cent complete sensory recovery.

Musculospiral nerve—62 per cent complete motor recovery ; 33 per cent complete sensory recovery.

B. Neurolysis—117 operations.

43 per cent full motor recovery ; 10 per cent full sensory recovery.

These figures include both *interim* results and *true end-results.*

Platt (Manchester) 1921 :—

150 operations—gunshot injuries.
Type of operation—end-to-end suture. Standard of recovery—neurological. Standard of failure—no appearance of conduction after one year or longer.
Musculospiral nerve—35 operations. Recovery in 26 ; failure in 9 (in 5 sutures of posterior interosseous nerve to main trunk).
Posterior interosseous—1 operation. Failure.
Ulnar nerve—47 operations. Recovery in 41 ; failure in 6.
Median nerve—30 operations. Recovery in 27 ; failure in 3 (all in forearm).
Brachial plexus (infraclavicular)—3 operations. Recovery in 2 ; failure in 1.
Sciatic nerve—25 operations. Recovery in 18 ; failure in 7.
External popliteal nerve—9 operations. Recovery in 4 ; failure in 5.
Interim results in the majority.

Stopford (Manchester) 1923—unpublished figures—gunshot injuries. True end-results as illustrated in the type of recovery seen in 157 suture operations. In the majority of these cases the period of post-operative observation has extended over three years or more. In all the neurological syndrome has apparently reached a final and stationary stage. The standard of assessment is neurological, the motor recovery being recorded in terms of voluntary contraction. In many of the patients the economic capacity is known, but this information is of little use for statistical purposes.

Musculospiral nerve—37 cases.
Recoveries in terms of motor function :—

Proximal muscles	..	Supinator longus, Extensor carpi radialis longior, Extensor carpi radialis brevior.
Distal muscles	..	Extensor carpi ulnaris, Extensor communis digitorum, Extensor minimi digiti, Extensor ossis metacarpi pollicis, Extensor brevis pollicis, Extensor longus pollicis, Extensor indicis.

Proximal muscles plus distal muscles (complete) 20
Proximal muscles plus distal muscles (partial) 16
(Extensor brevis pollicis lacking in all.)
Proximal muscles only 1

In two cases of complete recovery the interval between the date of injury and the time of operation was three years and two years respectively. In many of the complete recoveries the extensors of the wrist do not function synergically.

Ulnar nerve—38 cases (upper arm 19, forearm 19).

Proximal muscles	..	Flexor carpi ulnaris, Flexor profundus digitorum.
Distal muscles	..	Ulnar intrinsics of the hand.

A. Upper arm.

Motor recovery	..	Proximal muscles plus distal muscles (partial) 12
		Proximal muscles only .. 7

Ulnar nerve (Upper arm)—*continued.*

Sensory recovery ..	Restoration of protopathic sensibility in	9
	Protopathic plus partial restoration of epicritic sensibility in	4
	No sensory recovery in ..	6

B. Forearm.

Motor recovery ..	Hypothenar muscles alone ..	8
	Hypothenar plus one or more of the intrinsics	9
	First dorsal interosseous alone	1
	No motor recovery	1
Sensory recovery ..	Protopathic plus epicritic (partial)	9
	Protopathic alone (complete 3, incomplete 3)	6
	Complete sensory recovery ..	1
	No sensory recovery ..	3

Median nerve—43 cases (upper arm 22, forearm 21).

Proximal muscles: Pronator radii teres, wrist flexors and long finger flexors.

Distal muscles: Median intrinsics of the hand.

A. Upper arm.

Motor recovery ..	Proximal muscles plus distal muscles (partial)	7
	Proximal muscles alone ..	15
Sensory recovery ..	Protopathic alone	11
	Protopathic plus epicritic (partial)	6
	No sensory recovery ..	5

B. Forearm.

Motor recovery ..	Thenar muscles	9
	No motor recovery	12
Sensory recovery ..	Protopathic alone	9
	Protopathic plus epicritic (partial)	10
	No sensory recovery ..	2

Sciatic nerve—27 cases.

Motor recovery ..	Internal popliteal plus external popliteal muscles	20
	Internal popliteal alone	7
Sensory recovery ..	Protopathic alone (complete) ..	2
	Protopathic alone (incomplete) ..	14
	Protopathic plus epicritic (partial) ..	6
	No sensory recovery	5

External popliteal nerve—12 cases.

Motor recovery ..	All muscles	6
	One or more muscles	6
Sensory recovery ..	Complete	4
	Protopathic alone	6
	No sensory recovery	2

2. RESULTS OF END-TO-END SUTURE.

The classical distinction between *primary* and *secondary* nerve suture is to some extent purely artificial, for it is often difficult to indicate the exact dividing line between the two procedures. The extreme perfection attained

after many so-called primary sutures in the case of clean-cut divisions has long been appreciated, and it is usual to compare such results with the incomplete type of recovery which is the rule in the majority of the secondary sutures. The essential difference from a prognostic point of view, however, is not concerned with the exact chronology of the suture, but rather with the contrasted types of lesion and the conditions under which the repair is carried out. The end-to-end sutures in gunshot injuries belong almost exclusively to the secondary class. Under the conditions of emergency war surgery the opportunities for the practice of immediate nerve repair rarely arose; further, in the highly-infected wound such attempts were with reason regarded as unjustifiable.

Factors which Determine Prognosis.

The information and conclusions as to the remote results of suture operations may best be approached by a preliminary consideration of those factors which are known to influence the standards of recovery. From these gross errors in operative technique are excluded.

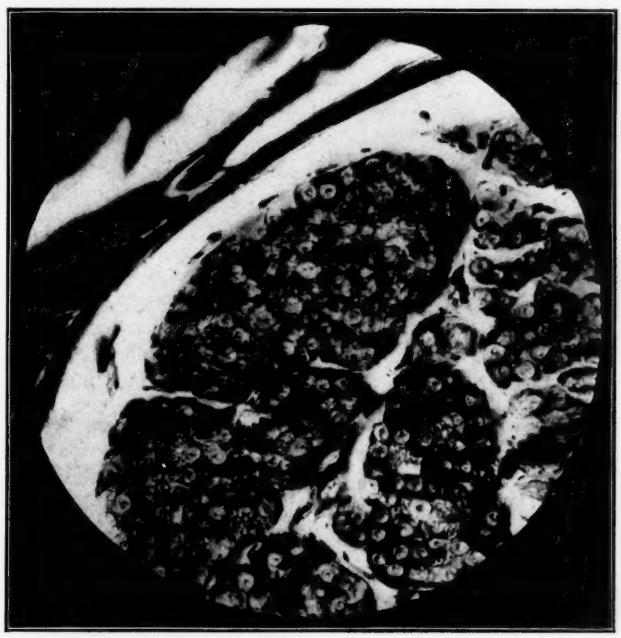


Fig. 315.—Cross-section of ulnar nerve 2½ in. above the lesion, showing interstitial fibrosis. The dark areas between and around the nerve-fibres consist of thickened endoneurium.

Changes in the Nerve-trunk itself.—These must be considered in three situations: (*a*) Above the point of suture; (*b*) About the site of suture; (*c*) Below the level of suture.

Many failures and partial failures may be caused by changes in the nerve which are beyond the control of the surgeon.

Through the courtesy of Dr. Greenfield, of London, and Dr. Linell, of

Manchester, who have kindly prepared the necessary sections, we are able to illustrate these points by means of microphotographs and drawings.

a. Changes Above the Point of Suture.—Of the changes which take place in the nerve proximal to the site of injury and to the suture, the first to be considered is interstitial fibrosis, in which the individual nerve-fibres are normal but the endoneurium is thickened.

i. *Interstitial fibrosis* is extremely common, and may extend far higher in the nerve than was at one time supposed. This has been particularly

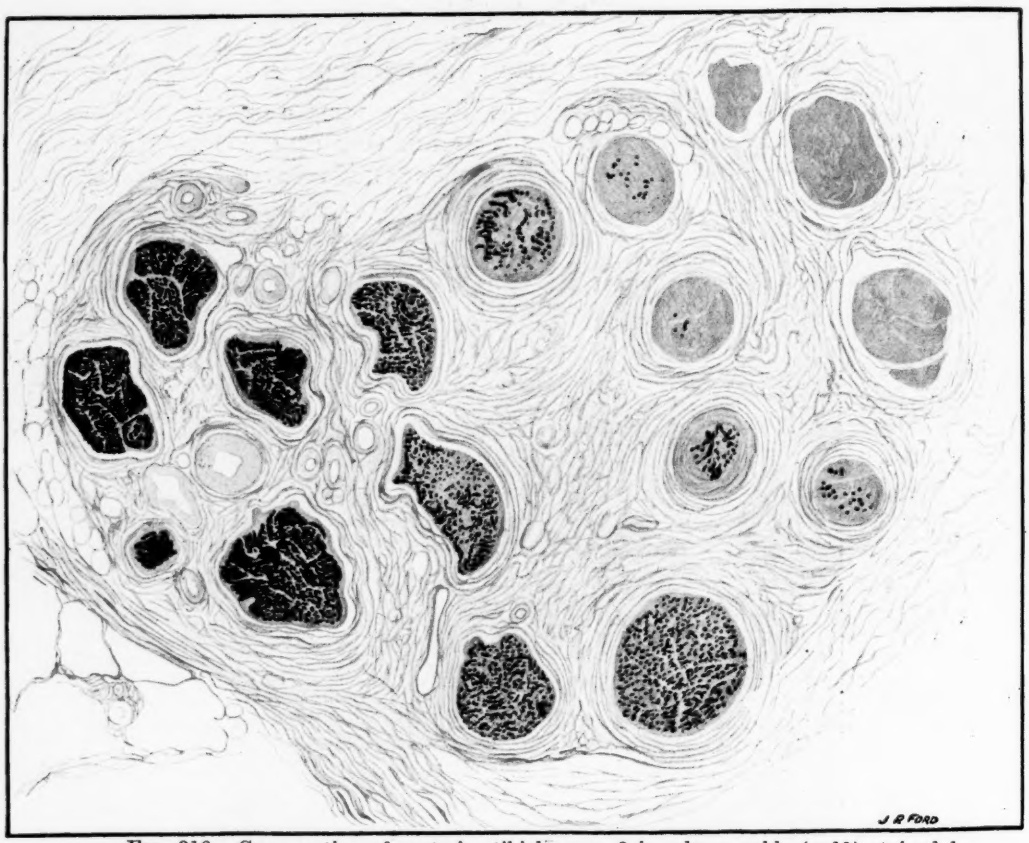


FIG. 316.—Cross-section of posterior tibial nerve 8 in. above ankle (×11) stained by Weigert-Pal method, showing demyelination on one side (*right*) of the nerve and partial demyelination of the bundles in the centre of the nerve. The bundles on the *left* show almost normal myelination. The bundles on the right are replaced by fibrous tissue, and there is a great excess of fibrous tissue between the bundles remaining.

marked in those cases complicated by sepsis, as were most war wounds. It may be quite impossible for the surgeon to get above the level of this change, as by so doing end-to-end suture would be rendered quite impracticable.

Fig. 315 illustrates this type of change in an ulnar nerve, 2½ in. proximal to the end bulb, and shows great thickening of the endoneurium. In this connection also the drawings in *Figs.* 316 and 317 must be considered. These are from a section taken from a posterior tibial nerve which was removed

from a patient whose foot had been amputated some years after sustaining a gunshot wound. The specimen is taken at least 8 in. above the site of the wound, and was obtained at the time of re-amputation in the middle third of the leg, an operation performed because of pain. The section shows interstitial fibrosis due to an inflammation spreading up one side of the nerve. The nerve bundles at this side are completely demyelinated, and in addition a good many bundles are replaced by fibrous tissue. Towards the middle

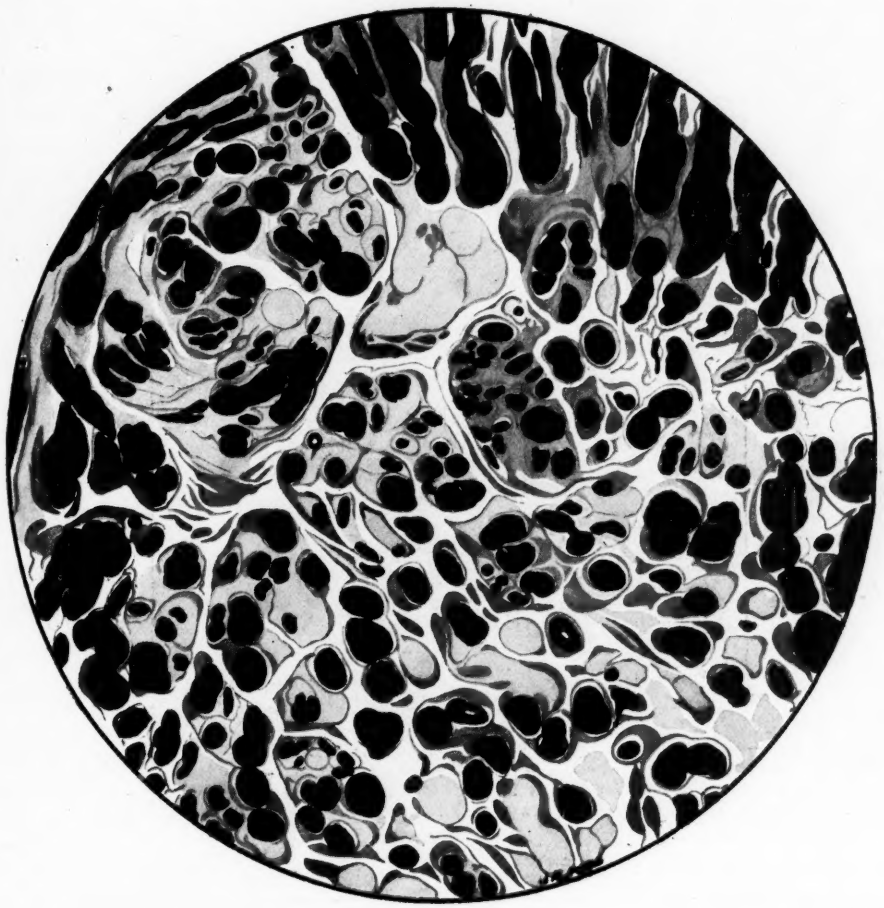


FIG. 317.—Cross-section of one of the more healthy bundles in *Fig.* 316 (× 190), showing intraneural fibrosis and demyelination of some of the fibres.

of the section one sees encroachment of the fibrous tissue on the bundles, whilst those on the opposite side are practically normal and well myelinated. Everywhere there is great thickening of interstitial fibrous tissue. This section illustrates in an extreme degree what is shown to a less extent in a considerable number of nerve lesions associated with pain.

ii. There is another type of change which may occur on the proximal side of the injury, viz., *an ascending toxic neuritis*. This condition is well illustrated in *Fig.* 318, which is taken from the sciatic nerve above the site

of the lesion from a patient in whom neurolysis had failed to bring about improvement, and whose leg was ultimately amputated for atrophy and trophic changes. The section shows nerve-fibres separated by œdema and fibrous tissue. Some appear normal with a central axis cylinder, wide myelin sheath, and surrounding nucleated sheath of Schwann. Others have reverted to a protoplasmic condition, i.e., they appear in section as a solid mass of nucleated protoplasm with numerus clear dots which represent fine threads of myelin. The neurofibrils, which are very fine, do not stain. The condition indicates that degeneration has taken place in this nerve above this level, and is followed by a commencing regeneration.

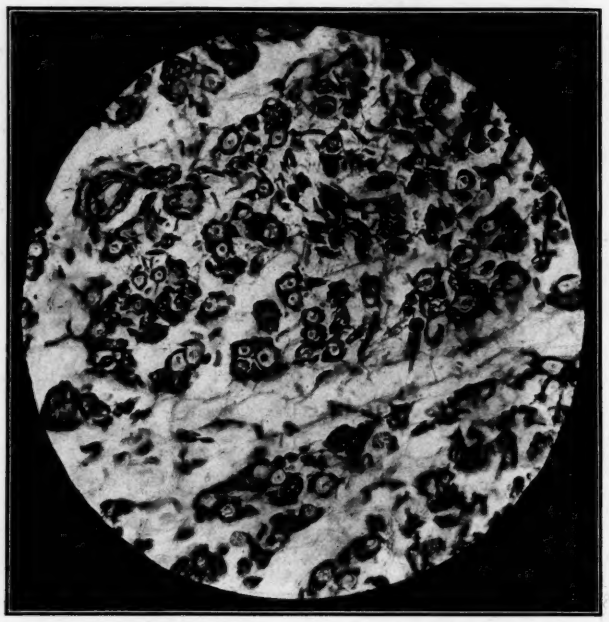


FIG. 318.—Cross-section of sciatic nerve above the level of the lesion (×75), showing separation of nerve-fibres by œdema and fibrous tissue. Many normal nerve-fibres are seen; others are regenerating, and are seen as almost solid protoplasmic rods in which the fine vacuoles represent thin threads of new myelin.

It is apparent from a consideration of these specimens that it is not possible in many instances to get above the site of damage in the central end of a divided nerve when the end bulb is resected and end-to-end suture performed. Moreover, it is not always possible, on examining the freshly-cut end at the time of operation, to appreciate the true state of affairs, and what changes, if any, are present in this part of the nerve.

b. Changes About the Site of Suture.—These include tissue reactions due to the stitch itself and to sepsis, even when mild, and which give rise to none of the ordinary signs of inflammation on clinical examination. The changes are essentially cicatricial, and, when well marked, shrinkage of the suture neuroma may follow some time after its formation.

In this connection a consideration of the drawing taken from a section kindly supplied by Mr. Sargent and Dr. Greenfield will repay investigation

(*Fig.* 319). The history is as follows: A nerve-grafting operation was performed in 1918 for a large gap in the ulnar. Three years and four months later the graft was exposed, no recovery having taken place. The drawing shows a reaction round a stitch in process of slow absorption. The stitch is of silk material. When seen with a dark-ground illumination there are small portions of stitch material elsewhere in the field. The stitch and the reaction round it represent more than *half* of the transverse section of the nerve.

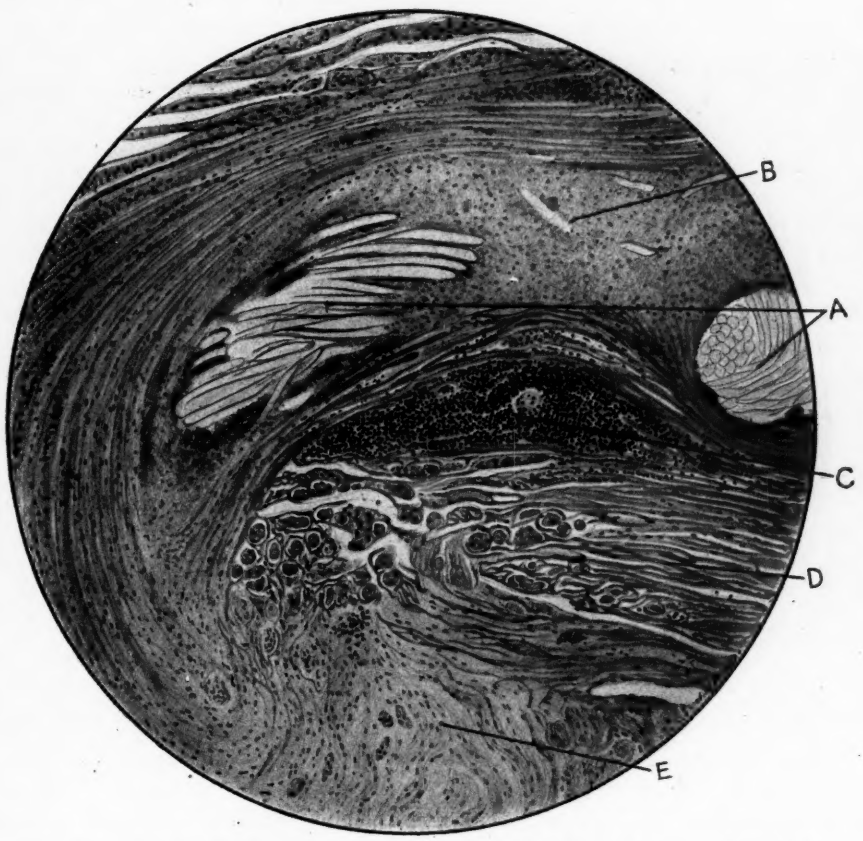


FIG. 319.—Longitudinal section of neuroma above junction of proximal end of nerve with graft, stained hæmalum and van Gieson (× 64). Showing (A) Remains of silk suture; (B) Mass of phagocytic cells absorbing suture material; (C) Area of small round-celled infiltration; (D) Fibrous-tissue overgrowth; (E) Nerve-fibres forming neuroma.

The point to be emphasized here is that there is a good deal of reaction even with the finest possible suture material, and such a reaction must to some extent jeopardize the completeness of recovery.

c. Changes Below the Level of Suture.—The section of the posterior tibial nerve illustrated in *Fig.* 320 shows that for some unknown reason regeneration may reach a certain stage, and then halt. The microphotograph in this instance is taken from a section of the nerve many inches below the site of repair, and two years after end-to-end suture had been performed.

Regeneration of axis cylinders, but with little or no re-formation of myelin, may well be a common end-result in a healed nerve.

The Period of Delay between the Original Injury and the Operation (Time Factor).—It was pointed out many years ago by Bowlby that after a certain optimum period—arbitrarily estimated as two years—recovery tended to be less certain and less complete. The truth of these observations has been confirmed by most subsequent writers, and the importance of early repair of a nerve lesion has always been stressed. Our more recent experience tends to bear out this conception. It is, of course, impossible to state dogmatically the exact period of delay beyond which an operation is doomed to complete failure. For practical purposes a three-year limit is a useful working basis. Stopford's extensive clinical statistics on the results of nerve suture seem to show that the optimum period is longer in the case of operations in the proximal part of the limb. It was the considered opinion of the Medical Research Committee on Peripheral Nerve Injuries that, so far as is known, no period is so long as to preclude the possibility of recovery. The harmful effects of long delay depend on the development both of peripheral and central retrogressive changes. The permanent degenerative changes which occur in the muscle bellies after prolonged denervation render these structures less capable of assuming function even though neurotization be established at a later date. But if they have been kept in the best possible condition as regards nutrition, by heat, massage, and electrical stimulation, the outlook is improved. It has been shown experimentally that if union be prevented after division of a peripheral nerve-trunk, a not inconsiderable number of the cells of the anterior cornua and posterior root ganglia disappear completely. It is thus probable that with increasing periods of delay the regenerative process itself is less efficiently initiated and controlled by the spinal centres.

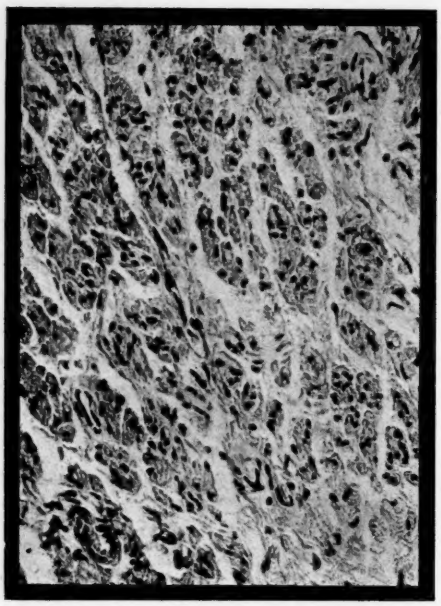


FIG. 320.—Cross-section of posterior tibial nerve, stained with hæmalum and eosin (× 75), several inches below point of suture. There is no interstitial fibrosis. The nerve-fibres are seen as solid protoplasmic rods, and not, as in the normal case, as axis cylinders surrounded by a thick myelin sheath. The protoplasmic rods contain many nuclei of the sheath of Schwann, and a few neurofibrils, but no myelin.

The Anatomical Situation of the Sutures.—Stopford (loc. cit.) has shown that when the proximal and distal parts of the limb are compared, sutures in the latter situation show a higher percentage of failures. The reasons for this are complex. It would appear that the regenerative control exercised by the spinal cells is less efficient when the point of section is far distant.

Topographical Confusion in Regeneration.—Inaccuracies of regeneration due to the shunting of nerve-fibres along inappropriate channels must of necessity be present after every nerve suture. In a clean-cut division of a nerve followed by immediate repair, with the avoidance of torsion of either proximal or distal stumps, such errors are minimal, and give no clinical evidence of their presence. But in the more extensive lesions in which a generous trimming or resection is necessary, a considerable disturbance of the intraneural pattern results. The regeneration in such cases may be compared with the process of nerve-crossing in miniature. Such regenerative errors are undoubtedly represented in the imperfections of the neurological and functional results which characterize the greater proportion of the suture operations in the case of the more extensive gunshot lesions. The known superiority of the results of suture of the *musculospiral* nerve, as compared with the *median* and *ulnar* nerves, illustrates very clearly the part played by this factor. The chances of topographical confusion are especially great also in the case of suture of a nerve of small calibre to a larger trunk, e.g., the posterior interosseous to the musculospiral, or the anterior tibial or musculocutaneous to the external popliteal trunk—operations which appear always to be followed by more or less complete failure.

It will be seen from the statistics quoted above that the results of the majority of end-to-end sutures performed for gunshot lesions are imperfect in a neurological sense. The picture is not, however, such a gloomy one as might appear at first sight, for in the uncomplicated cases the economic standard of recovery is often surprisingly good. There are, moreover, great discrepancies between the results obtained in the case of the different nerves. A study of *true end-results* in a series of operations which have been followed from the beginning shows quite clearly that the mere appearance of signs of recovery in the early stage is no guarantee that such recovery will be progressive.

Comparison Between the Different Nerves.

Musculospiral Nerve.—All statistics show that this nerve heads the list of recoveries, whether judged from a qualitative or quantitative standpoint. Almost perfect restoration of function has been described in a considerable number of cases, e.g., 20 out of 37 in the end-result series of Stopford. At the same time, a careful examination has shown that, in the majority of these highly successful results, the synergic action of the extensors of the wrist is lacking. It is probable, however, that this deficiency may be remedied by assiduous training after years of occupational use of the hand.

Ulnar Nerve.—In this nerve the results have been physiologically imperfect, but not necessarily economically bad. Complete restoration of function in the ulnar intrinsic muscles of the hand appears to be unknown, whilst full sensory recovery is also a phenomenon of extreme rarity. The average sensory result involves the restoration of 'protopathic' sensibility alone. There is less difference in the quality of the results obtained in the forearm sutures, as compared with the upper arm sutures, than was foreshadowed in some of the *interim* statistics. Many individuals with complete lesions of the ulnar nerve have been known to be capable of engaging in

laborious occupations such as dock-labouring, coal-mining, and so forth. But the musician, the artist, and the fine manual worker are seriously handicapped by the incomplete recovery of the muscles of the hypothenar eminence, the interossei, and the adductors of the thumb.

Median Nerve.—The results in the case of this nerve have been uniformly disappointing, chiefly owing to the extreme functional disablement consequent on the inadequate recovery of sensibility. This nerve illustrates very beautifully how co-ordination in finer movements is dependent on the complete restoration of the paths for all types of afferent stimuli. A reference to the details of sensory recovery in Stopford's series shows that at the very best there has been little more than the reappearance of full protopathic function, whilst in 16 per cent of the operations no sensory recovery was seen. In more than half in the same series there has been no neurotization of the thenar muscles. The latter disability, however, is usually overshadowed by the effects of the sensory loss, which is manifested most dramatically by the helpless index finger. There is also another type of relative failure seen sometimes after suture of the median nerve, viz., the recurrence and persistence of inveterate pain and hyperæsthesia.

Sciatic Nerve.—Here the neurological and economic results have been consistently poor. No case is on record where recovery has been demonstrated in the intrinsic muscles of the foot. The type of sensory restoration has been on the average exceedingly defective, and this has constituted in many patients a source of danger from the tendency to the development of traumatic ulceration in the foot. The earlier and more complete recovery seen in the calf muscles, as compared with the anterior tibial group, has often been instrumental in determining the production of a contracture in patients who have lacked post-operative supervision. As in the case of the median nerve, irritative phenomena are occasionally seen, and add to the serious psychical and physical disablement of the individual.

External Popliteal Nerve.—The percentage of complete failures has been high in the case of this nerve; but, on the other hand, very complete types of recovery have been described. In uncomplicated lesions the economic capacity of the individual provided with an efficient walking apparatus is very satisfactory.

Of the results of suture of the less commonly injured nerves the information is too scanty to merit a detailed discussion.

3. RESULTS OF NEUROLYSIS (FREEING OR LIBERATION OF THE NERVE).

It is difficult in many cases to define how far the operations of this class have brought about the recovery which has been seen to follow their application. In many nerve injuries belonging to the category of pure compression lesions, the surgical removal of the compressing agent is rapidly followed by the reappearance of both conductivity and function. This means that the loss of conduction has not been associated with actual degeneration of the axis cylinders. The effect of a neurolysis under these conditions is to restore the mobility of the nerve-trunk in the injured area by eradicating a factor which is the direct cause of a cumulative intraneural trauma dependent on the repeated stretching and friction of the anchored nerve during the natural

movements of the part. Where a compression lesion has been in existence for some considerable time, the restoration of conduction now depends on the occurrence of regeneration alone, and the obstacles to the full attainment of such spontaneous repair are situated in the interior of the nerve-trunk, i.e., the interstitial fibrosis of a traumatic neuritis. Thus, after the elimination of the cause of the trauma at a late stage, there is no certainty of achieving a complete restoration of function. This sequence of events is shown quite clearly in the results of the operative treatment of compression neuritis of the lower trunks of the brachial plexus produced by the various types of supernumerary cervical rib. In 31 of the large series of cases operated on and recorded by Sargent,[7] muscular atrophy was the predominating symptom. Full recovery of bulk and strength in the affected muscles was seen after operation in 12 only.

The problem in the extensive lesions due to gunshot injuries is somewhat more complicated, for it would appear that extraneural scar tissue usually plays a minor rôle in the production of loss of conductivity. It is therefore difficult to prove that, following the removal of such scar, the later recovery of conduction and function is due to the operation alone. In the graver lesions where the nerve retains its continuity, neurolysis is often legitimately an experimental procedure, to be followed by resection and suture at a later date if signs of recovery do not ensue. It is for these reasons that we do not discuss at great length the results which appear in the statistics already quoted; nor does it seem logical to compare neurolysis and suture results as if they were those of equivalent operations.

Several variants of the operation of simple neurolysis have been practised. The procedures known as 'hersage' and 'endoneurolysis' have met with little approval in this country. Capsulectomy-neurolysis—i.e., the peeling off of the outer layers of the thickened sheath of a fusiform neuroma (nerve spindle)—has been followed by striking improvement in some cases. (Joyce.[8])

4. BRIDGE OPERATIONS.

This term is applied to the various methods of filling in an extensive gap in the continuity of a nerve-trunk. Such operations have been practised for many years, and, as a result of much clinical and experimental research, the question of their value has been more or less finally settled. The following methods have been in vogue in the past, and were probably tried by most surgeons during the war period (1914–1918).

a. **Neuroplasty,** i.e. the bridging of a gap by the turning down of a flap from the proximal to the distal nerve stump, or vice versa. This type of operation may be dismissed at once as having been proved both illogical and futile. (Stookey.[9])

b. **Tubulization,** in which some form of conducting channel is inserted, such as a tube constructed of fascia, blood-vessels, or some foreign material. These operations have also failed to establish themselves as procedures of any value in peripheral nerve surgery.

c. **Nerve-grafts.**—Many of the earlier reported successes in nerve-grafting do not bear scrutiny in the light of modern experience of the many pitfalls

which accompany the interpretation of the clinical signs of recovery. It is generally agreed that down-growing axis cylinders may cross a short gap, utilizing the channels afforded by a graft, whether this be of an autogenous, homogenous, or heterogenous nature. Where a gap is filled in by a graft equal in size to the injured nerve or by multiple small grafts arranged in cable fashion, a sufficient number of axons may in theory be conveyed into the distal nerve-trunk, and thus ensure adequate function. Autogenous cable-grafts, and large homogenous single-trunk grafts, have been used extensively in recent years by the American and French surgeons, but have rarely been employed in this country. A considerable literature has now accumulated dealing with the general failure of such operations. It is fair to state, however, that evidences of regeneration may be seen when a *short* gap is bridged by a large graft or number of grafts which reproduce the full calibre of the injured nerve-trunk.

The writers have had the opportunity of examining a considerable number of patients who have been subjected to nerve-grafting operations, including those examined and reported on by the Medical Research Council and referred to in the Addendum of the Report published by that body. The majority of these operations were complete failures; but in a few, evidence of partial recovery was established. In one patient a gap of 3½ in. in the ulnar nerve in the arm had been filled in by a portion of the internal cutaneous removed from the same limb. Three years and three months later there was recovery of voluntary power and faradic excitability in the flexor carpi ulnaris, flexor profundus digitorum, and the abductor minimi digiti. There was little recovery of sensation, as complete anæsthesia to light touch persisted, whilst appreciation of pinprick over the little finger was imperfect. A second patient who showed evidence of some recovery was a man with a musculospiral injury which had been grafted with alcoholized human nerve. Two years and four months from the date of the operation there was recovery of voluntary power in the supinator longus and the wrist extensors. There was no recovery in the thumb extensors, nor could the fingers be voluntarily extended. These two patients represented the best results of nerve-grafting we have seen.

In irreparable injuries of certain nerves, where no alternative operation for the restoration of function is available, a graft operation may thus be legitimately practised. But the cases calling for this treatment are few, and become still fewer with increasing experience. The surgeon must not lessen in any way his efforts to obtain end-to-end suture, even by a two-stage operation, no matter how exhausting and tedious the procedure.

The attitude of British surgeons towards the value of nerve-grafts continues to be one of scepticism.

d. **Nerve-crossing — Lateral Implantation. (Nerve Anastomosis.)**— Various types of nerve-crossing have been tested, both in experimental work and in the actual operative repair of nerve injuries. In the latter case the distal stump of the injured nerve must be brought into contact with divided axis cylinders in a neighbouring nerve. There are certain obvious *a priori* anatomical and physiological objections to this method of indirect nerve repair. When efficiently performed, the operation involves considerable

damage to the reinforcing nerve; and for reasons concerned with topography, an anastomosis between important mixed nerves is bound to be a haphazard proceeding. The successful cases of nerve-crossing recorded in the literature in the past appear to be limited to operations for injuries of the supraclavicular trunks of the brachial plexus, and of the facial nerve. In seven examples of implantation of the distal end of the ulnar (injured nerve) into the median nerve examined by Stopford and one of the writers (H. P.), there were failure of regeneration and signs of interference with the conduction in the median nerve in all.

It is only fair to record that Joyce showed two patients on whom he had performed a double lateral implantation to the Medical Research Committee, which reported as follows:—

"In the case of an *ulnar nerve* which had been divided in the middle of the forearm, an incision had been made across one-third of the median nerve, and the proximal cut end of the ulnar had been sutured to the distal face of the section. A similar incision across one-third of the median nerve had been made 3½ inches lower down, and the distal end of the divided ulnar sutured to its proximal face. Examined two years later, the condition was as follows: Doubtful voluntary contraction was present in the abductor minimi digiti, but both this muscle and the abductor indicis responded to faradic stimulation. Pin-pricks were appreciated within the whole ulnar area except over the terminal phalanx and the ulnar border of the middle phalanx of the little finger. Deep sensibility was present in the whole ulnar distribution. No defect could be demonstrated in the functions of the median nerve.

"In the case of a divided *median nerve*, the proximal and distal segments had been implanted laterally into the sheath of the ulnar nerve, every effort having been made not to injure any fibres of the ulnar. Examined thirty-four months after this operation, the condition was as follows: The radial border of the metacarpal bone of the thumb could be distinctly seen and felt, but the thenar eminence as a whole was very little wasted. The abductor brevis pollicis reacted briskly to a strong faradic current, although it was doubtful whether the patient could contract the muscle voluntarily. The action of the opponens, whether voluntary or to faradic stimulation, could not be definitely decided. The patient was able to appreciate pin-pricks over almost the whole of the terminal phalanges of the index and middle fingers. Sensibility to cotton-wool was wholly absent. Deep sensibility was perfect, but the lesion of the nerve was too low for it to have been originally affected."

In this country one or two surgeons still practise and champion nerve-crossing operations; but, as far as we know, they are not subscribed to by the majority, and are generally condemned for the reasons given above.

III. RESULTS OF OPERATIONS FOR THE RELIEF OF PAIN AND OTHER IRRITATIVE PHENOMENA.

In the main, the gunshot injuries of peripheral nerves have given rise to but little in the way of pain, although milder irritation symptoms have been seen not infrequently. In a few cases pain has been severe.

Clinically, it is of the greatest importance to differentiate between the pain of true *causalgia* and the pain evoked by stimulating a recovering nerve area. At a certain stage in recovery any stimulation in the area of sensory supply which is felt at all is appreciated as pain. This is a normal phenomenon which exists in most recovering nerves for a short time, but in some rare cases has been known to persist for long periods. This type of pain must not be mistaken for causalgia; it is not spontaneous, has no emotional causation, but is the direct result of stimulating an area of skin which is no longer anæsthetic but which can appreciate pinprick and pressure, but cannot appreciate the fine degrees of sensation, e.g., light touch (epicritic sensation).

Illustrative case.—Following a lesion of the internal popliteal in a patient (Capt. W.), recovery reached this stage and remained stationary for fifteen months. The nerve showed no sign of further regeneration, and the state of the patient was intolerable. Any pressure on the sole of the foot was painful, and he was unable to walk or even stand with full weight on the limb. This limb was eventually amputated below the knee. The histological changes in the posterior tibial nerve are illustrated in *Fig.* 320 and have already been discussed. The association of imperfect myelination with the persistence of signs of irritation is suggestive.

In causalgia (first described by Paget and named by Weir Mitchell) there is severe pain, spontaneous in onset and of a burning character. It is intense and persistent in type, and subject to exacerbations. It is brought on by causes other than physical; the paroxysms may be induced by the banging of a door, sudden movement, or indeed by any factor which plays on the emotions. The patient may walk about, or sit huddled in a corner, the limb wrapped in a wet cloth, the picture of misery and mental anguish. He avoids any and every form of stimulation, and shuns his fellows. The hunted, haggard expression of a patient with true causalgia when once seen will not be forgotten. In many cases the loss of conduction is slight, and is completely overshadowed by the sensory manifestations.

In the minor grades of the irritation syndrome, non-operative measures alone have often brought about complete relief, and in a certain proportion of cases of causalgia proper, the timely exhibition of drugs, combined with psychotherapeutic treatment, has rendered operative interference unnecessary. In the majority of cases of the latter condition, however, it was found advisable to explore the injured nerve.

The following operative procedures were commonly practised in this country:—

Neurolysis.—Simple freeing of the nerve is generally quite effective in relieving the milder forms of irritation, but was found to be of little value in true causalgia.

Resection and Suture.—Gratifying results have been seen after this operation, which is to be regarded as one of the two methods of choice.

Intraneural Injection of Alcohol.—In practised hands this procedure has given results equivalent to those seen in resection and suture.

The operation of *posterior root section* has been carried out in a few grave cases where resection and suture failed, but it is agreed by most

authorities that this procedure should be advised under exceptional circumstances only.

The *operation of Leriche*[10] (peri-arterial sympathectomy) has gained few adherents in this country, and no figures are available as to its value in the hands of British surgeons.

There are few published statistics dealing with the results of the operative treatment of causalgia, so that the following series of one of the writers (H. P.) may be quoted.

Median Nerve—14 operations in 11 patients.

1. Resection and suture—11 (two on the same nerve).
   Success: complete relief of pain—9.
   Failure: incomplete relief of pain—2 (same patient); cause of failure, interstitial fibrosis above level of resection.
2. Neurolysis—2.
   Success: nil. Re-exploration in both—resection and suture.
3. Injection of quinine and urea—1
   Incomplete relief. Gradual subsidence of irritation after one year.

Sciatic Nerve—11 operations.

1. Total resection and suture—9.
   Success: immediate—9.
   Failure: immediate—none; remote result—return of irritation symptoms during regeneration—2.
2. Segmental suture of internal popliteal half—1.
   Immediate success. Severe irritation during regeneration.
3. Neurolysis—internal popliteal—1.
   Relief of pain.

IV. RESULTS OF OPERATIONS DESIGNED TO RESTORE FUNCTION IN IRREPARABLE LESIONS OR IN CASES OF INCOMPLETE RECOVERY.

The problems afforded by the irreparable nerve lesions, and the cases of incomplete recovery after nerve suture, differ in degree but not in type. The operations applicable under such circumstances consist in: (1) Attempts to restore motor function or to achieve a reasonable degree of compensation; and (2) As a last resort the elimination of a useless, dangerous, or painful limb. Similar restorative procedures have long been practised for the residual paralyses of anterior poliomyelitis. In the case of incomplete recovery after suture, it is important, from an economic standpoint, to decide whether the condition is to be regarded as final and all treatment discontinued, or whether it is worth while performing some alternative operation. Months and years may be wasted in a vain attempt to improve function by massage, electricity, and allied physical treatment in patients in whom recovery has reached its final stage. Many patients who have had a divided *sciatic nerve*, and in whom little or no recovery of nerve conduction has been regained, particularly on the sensory side, have a better industrial outlook when the limb is amputated. A great number of such amputations have been performed, and many are still to be performed, with definite benefit to the war-pensioner. The thin, wasted, atrophic foot, particularly liable to pressure sores—often incorrectly called trophic ulcers—is an encumbrance, and in such cases a below-knee amputation and a well-fitting artificial limb materially lessen the final disability.

Amputation is sometimes called for to remove the stiff, contracted fingers following incomplete recovery in a lesion of the *ulnar nerve*, for in these cases the operation of arthroplasty on the interphalangeal joints has been disappointing in its results.

Failures or partial failures after operations on the *musculospiral nerve* have been very successfully treated by tendon transplantation. The exact technique and details of this procedure will vary, but in the main the operation which has been most efficient is as follows—(it was originally devised by Sir Robert Jones) :—

Transplantation of the

Pronator radii teres into the extensores carpi radiales longior and brevior,

Flexor carpi ulnaris into the extensor communis digitorum and extensor longus pollicis.

Flexor carpi radialis into the extensor ossis metacarpi pollicis and extensor brevis pollicis.

The results of this operative procedure are striking—a useful and strong hand is obtained, a hand capable of being utilized for most ordinary occupations.

Other tendon transplantations are occasionally of service to assist function, e.g., after lesions of the *median nerve* to restore some power in opposing the thumb ; but these are not commonly practised.

Where there is no recovery after lesions of the *external popliteal nerve*, attempts have been made to remedy the resulting foot-drop by tenodesis, i.e., the converting of the paralysed dorsiflexors of the foot into ligaments by attaching them to the tibia. These newly-formed ligaments tend to stretch, and for this reason the operation is not often employed. It has been found that a light side-iron, with a toe-elevating spring attached, yields a better functional result in the majority of patients.

The residual disability following a fairly successful nerve suture is often capable of improvement by simple operative means if the patient is carefully examined and his exact disablement analysed. As examples may be quoted the short tendo Achillis, or fixed flexion deformity of the interphalangeal joint of the great toe following a sciatic injury. Such disabilities are not infrequently overlooked.

SUMMARY.

1. The results of *end-to-end suture.*

The results of end-to-end suture in the case of gunshot lesions are for the most part imperfect both from a neurological and economic standpoint. In an average large series of consecutive operations, complete failures will be found in about 20 per cent.

a. The *musculospiral nerve* heads the list of recoveries, and may be expected to show practically complete restoration of function in at least 50 per cent of the successful cases.

b. The *ulnar* and *median* nerves give disappointing results on the whole. In the former complete recovery in the intrinsic muscles of the hand is so rare as to be almost unknown ; in the cases showing recovery neurotization

of the hypothenar muscles alone is fairly constant. The economic results, however, in this nerve are often good, except in individuals whose occupation demands the finer co-ordinated movements of the fingers. In the *median* the sensory recovery is always inadequate, and this factor is the cause of the great depreciation in the function of the hand. In sutures of the median in the forearm, complete failure of recovery in the thenar muscles is frequently seen.

c. The results of *sciatic nerve* sutures are poor, and a considerable number of such limbs come ultimately to amputation.

2. The outstanding causes of failure or imperfections—apart from *delay*, or gross *errors* in operative technique—are (*a*) Changes in the nerve above the line of suture—either interstitial fibrosis or an ascending neuritis—due in either case to wound infection; (*b*) Topographical confusion in regeneration.

3. The operations of *indirect nerve repair* (with the possible exception of nerve-grafting) have proved ineffective, and should be eliminated from the repertoire of peripheral nerve surgery. Investigations of the results of a small number of nerve-grafting operations in this country suggest that these procedures are of limited value.

4. In the nerve lesions associated with profound irritation (causalgia), resection and suture, or the intraneural injection of 70 per cent alcohol, will rarely fail to bring about immediate and complete relief of the pain, but at the cost of the signs and symptoms associated with complete division of that nerve.

In conclusion, we would wish to make it clear that although a fair and critical survey of the nerve injuries of the war must leave us pessimistically inclined, yet there is a brighter side to the picture. War injuries are complicated by sepsis; but the prognosis for the nerve injuries of civil life must be vastly better, and the experience gained in nerve surgery on the scale which has been possible will help to crystallize our ideas for the benefit of the patient, and for an improvement in surgical teaching.

The writers are particularly indebted to Professor J. S. B. Stopford for placing at their disposal statistics hitherto unpublished, and to Dr. J. G. Greenfield, who, in addition to the preparation of histological specimens, has given much helpful advice and criticism.

A CRITICAL SUMMARY OF THE DISCUSSION UPON THIS SUBJECT AT A MEETING OF THE SIXTH CONGRESS OF THE INTERNATIONAL SOCIETY OF SURGERY, HELD IN LONDON ON JULY 19, 1923.

In the summary which follows certain comments or criticisms are interposed which are meant to interpret, in the judgement of the writers, the views of those British surgeons who have had special experience in this field of surgery. As in the case of the British report, the discussion was limited almost entirely to a consideration of the peripheral nerve injuries peculiar to warfare.

Dr. Henriksen, of Skien, in presenting the opening report, stated that after a nerve had been divided cleanly it showed a tendency to heal spontaneously. Sensation in the anæsthetic area returned almost at once, and motor power reappeared in about two months. The results were the same whether the nerve was simply cut by a sharp instrument or whether suture was performed after a preliminary resection. He thus considered that primary suture was followed by immediate healing and restoration of function; and further that a cleanly performed secondary suture yielded an equivalent result and in the same short space of time. The majority of those taking part in the debate were not in agreement with Henriksen. It is almost universally conceded that errors of interpretation explain the abnormally early clinical signs of recovery.

Dr. Henriksen then dealt with certain factors which prevented healing: (1) The interposition of fat, or of scar tissue resulting from sepsis; (2) The degree and extent of the local damage. He regarded a crush or severe bruising of the nerve as a serious obstacle to the occurrence of spontaneous regeneration. The injury sustained by the nuclei of the sheath of Schwann might prevent recovery, for if nuclei were destroyed on a large scale, no new nerve fibres were formed and the nerve atrophied. It may be stated here that Henriksen is a strong adherent of the peripheral theory of regeneration, which he has supported by a good deal of careful experimental work.

Dr. Gosset, of Paris, presented a full report of his own work, and quoted also that of other leading French surgeons. Tables showing his own personal results and also those obtained by other observers are given on the opposite page.

He divided the substance of his contribution into three parts:—

1. Injuries of Nerves requiring Operation:—

a. All cases of compression which tend to progress and lead to serious interruption or show evidence of irritation. He considered that liberation of the nerve—neurolysis—should be undertaken in all these cases without delay. The operation was of the nature of an exploration, and could harm neither the patient nor the nerve when carefully performed.

b. All cases of complete interruption. Gosset stressed the importance of an exact diagnosis, as far as this is possible. He emphasized the necessity of repeated examinations by skilled neurologists. Nerves showing no signs of regeneration, or in which regeneration had reached a particular stage and then ceased, required operation.

c. All cases of causalgia or serious neuritis usually required operation, but for these difficult conditions no exact rules could be laid down; such cases must always be considered on their merits.

2. The Time of Operation.—Early operation was advisable as a general routine:—

a. In war surgery the condition of the main nerves should always be investigated and noted during the preliminary surgical cleaning of the wound. Any severed nerve should be sutured at once, in order to prevent deviation or displacement, the interposition and growth of fibrous tissue between the cut ends, and also in order to permit of rapid regeneration. If the nerve

is found to be bruised but not divided, it should be preserved and kept under careful observation.

b. If a period of time has elapsed before the patient comes under observation, and a nerve lesion is diagnosed, operation should be undertaken at the earliest possible moment; but as asepsis is essential, it is imperative to wait until all signs of inflammation have disappeared for some weeks.

DR. GOSSET'S TABLE TO SHOW THE PERCENTAGE OF COMPLETE SUCCESSES OR MARKED IMPROVEMENT.

NERVE	NEUROLYSIS	SUTURE
Musculospiral	95 per cent	45 to 55 per cent
Median	47 ,, ,,	44 ,, ,,
Ulnar	43 ,, ,,	17 ,, ,,
Sciatic—trunk, 1917	55 ,, ,,	35 ,, ,,
,, ,, 1920	—	40 ,, ,,
Sciatic—external popliteal ..	66 ,, ,,	50 ,, ,,
Sciatic—internal popliteal ..	—	40 to 50 ,, ,,

TABLE TO SHOW THE COMPARATIVE PERCENTAGE RESULTS IN THE PRACTICE OF VARIOUS SURGEONS.

SURGEONS	NO. OF CASES SUTURED	SUCCESSES OR MARKED IMPROVEMENT	IMPROVEMENT	FAILURE
		Per cent	Per cent	Per cent
Cestan	23	—	74	26
Dane	98	50	—	—
Delagénière	236	—	88	—
Donati	—	46	34	20
Féré	20	55	15	25
Forgues and Jumentié ..	22	14	45	41
Gosset and Charrier, 1917 ..	140	45	—	—
Gosset and Charrier, 1920 ..	54	50	25	25
Joyce	36	37	23	40
Platt	150	—	79	21
Putzu	40	—	37	—
Wayre Babcock	170	—	25	—

3. THE TYPE OF OPERATION ADVISABLE :—

a. Neurolysis—simple liberation of the nerve, and its reposition in a new bed between healthy muscles—is applicable where the syndromes of compression or irritation are present. Foreign bodies embedded in the nerve should be removed. The removal of fibrous tissue from between the nerve bundles should only be practised when this can be done without damaging the healthy part of the nerve.

b. Resection, and suture of the sheath, without traction, should be undertaken for complete division, or when the nerve fails to show signs of regeneration after several examinations. If end-to-end suture is not possible, a graft should be inserted. Gosset emphasized the importance of physical treatment

in both the pre- and post-operative stages, in order to prevent ankyloses and adhesions, and to keep the limb in the best possible condition. He pointed out that regeneration might go on from eighteen months to several years, and that treatment should be persevered with. He drew a sharp distinction between the end-results of immediate and delayed suture. Immediate suture, whether in civil or military surgery, should normally be completely successful. When a period of from one month to two years has elapsed between the injury and the suture, operation should yield 40 to 50 per cent of good functional results. After an interval of two years the proportion of successes was less, but suture should still be attempted. He considered that prolonged observation was essential, and that nerve surgery carefully and systematically practised by "specialists who are equipped for that purpose" yielded satisfactory results.

Dr. Gosset's report represented a most comprehensive survey of the whole subject. His conclusions in the main were similar to our own, excepting in so far as he did not mention the two-stage operation, and that he favoured nerve-grafting where end-to-end suture was not possible.

Professor C. H. Frazier, of Philadelphia, stated that the American casualties in the great war exceeded 200,000, and that of these about 3,500 had peripheral nerve injuries. With few exceptions the operations on which his report was based were performed by specially trained surgeons at one or other of twelve centres in the United States. As regards the time when operation should be undertaken, it was the general practice in America to defer operation until three months after the wound had healed. Experience had shown that signs of spontaneous regeneration might commence as late as six months after the time of the injury, and in rare cases at an even later date. He referred to a musculospiral nerve injury which showed the first sign of regeneration after a delay of twenty-one months. He knew of cases in which successful suture had been performed after a delay of two years between the time of injury and the operation. He considered that if there was no evidence of regeneration six months after the injury, or regeneration had failed to progress, or there was evidence of neuritis, operation was called for.

The damaged nerve should be resected sufficiently to expose healthy bundles above the site of injury, and end-to-end suture be performed. Six or eight silk sutures through the sheath were necessary, and a stay stitch (catgut) was sometimes used when the suture was of necessity under any tension. With increasing experience, the actual resection tended to become more extensive. Partial resection was a delicate operation and one which was seldom performed. Every effort was made by posturing the limb, by transposition of the nerve if practicable, and by extensive freeing, to get the ends into apposition; but when the gap was too great to allow of approximation of the freshened ends, Frazier advocated the two-stage operation in preference to bridging the gap by means of a graft. In his experience graft operations, with only a very few exceptions, had been uniformly unsuccessful.

As regards true end-results, the same difficulty had been experienced as in Great Britain. The patients had become widely scattered. He presented the following table, based on 496 cases operated upon, and made up as follows: end-to-end suture 350, neurolysis 132, grafts 14.

TABLE TO SHOW THE END-RESULTS OF NERVE INJURIES, BASED UPON 496 CASES OPERATED UPON.

NERVE	RESULT		
	Good	Mediocre	Negative
	Per cent	Per cent	Per cent
Brachial plexus	33	37	29
Musculospiral	23	30	46
Median	58	28	14
Ulnar	12	55	31
Sciatic	25	41	33
External popliteal	31	52	16
Internal popliteal	46	46	8

Recovery after suture was rarely perfect. It was difficult to account for the high percentage of failures in certain nerves, such as the external popliteal, and the question of the bearing of the intraneural plexuses upon this point had elicited divergent views in America. Frazier considered that the chances of success in the case of the median, ulnar, musculospiral, and sciatic nerves were sufficiently good to warrant re-exploration and suture if failure of regeneration persisted. Frazier's conclusions were thus very similar to those arrived at by British surgeons.

The paper prepared on the work of the Italian surgeons by the late Dr. Verga, of Pavia, was communicated by Dr. Chiasserini, of Rome. He called attention to the experimental work on peripheral nerve injuries which had been accomplished at the University of Pavia under the direction of Professor Golgi. He stated that the operation of choice was end-to-end suture, and that the results obtained by this operation and by neurolysis in suitable cases were far superior to those of grafting or any form of nerve-bridging.

Dr. Verga had prepared a summary of 82 cases observed for a period of over a year. The results showed: Recovery, 52·4 per cent; improved, 37·8 per cent; failure, 9·7 per cent. By recovery he did not necessarily mean a perfect neurological or functional result. Amongst his series were included cases in which there was some weakness and inability to stand fatigue, so that the limb became very easily tired. He regarded perfect recovery as exceedingly rare. He considered that the longer these patients were followed up, the more improvement was shown, and that improvement was often largely a question of time. In a small series of cases carefully watched over a period of six and a half years, improvement was noted in all. He made no mention of the two-stage operation for suture. He considered that grafting should not be condemned, as it might give good results, but should only be resorted to after failure of the more standardized procedures.

In the discussion which followed the papers by the reporters of the various countries, Dr. Chiasserini dealt with the question of nerve-grafting at greater length, and claimed to have had a successful result from the implantation of an alcoholized graft in the case of a divided median nerve in the forearm. In this case the sensory recovery was good, and the motor recovery fair. He

showed a series of lantern slides illustrating the results of nerve-grafting operations in experimental work on dogs. These experiments showed that some months after the operation the nerve appeared almost normal on naked-eye examination, and that on histological investigation nerve-fibres could be followed through the graft into the distal trunk. He considered that the almost universal failure of nerve-grafts in man was largely a question of faulty technique. He stated that a graft of approximately the same thickness as the injured nerve was needed, and should be placed in position either as a single trunk or as a cable graft—i.e., a series of smaller grafts placed parallel to each other and so filling up the gap. It may be remarked that cable grafts have been employed both in this country and in America, but with scanty success.

Dr. Leriche, of Lyons, continued the discussion and dealt with four main points: (1) The treatment of causalgia; (2) The results of Nageotte's dead heterogenous grafts; (3) The treatment of trophic troubles; (4) The possibility of improving the results of nerve operations.

He considered causalgia a vasomotor syndrome, and referred to his earlier work on the subject (1916) and to that of Pierre Marie and Meige. Causalgia did not necessarily clear up spontaneously, as had been considered usual by some authorities; he had examined two cases during 1923, one of whom was wounded in 1914 and the other in 1915. In his experience the condition could follow minor accidents, such as a crushed finger, which did not involve main vessels or large nerve-trunks. When it followed a nerve injury it was nearly always a median or sciatic lesion, and in either case the nerve possessed its own artery.

The condition was divisible into two phases—a peripheral and a central:

1. In the early or peripheral phase the operation of peri-arterial sympathectomy was often successful. In 9 cases he had obtained 5 very good results—the patients returning to a normal working life—2 partial successes, and 2 failures. The failures were due to the disease having reached its second or central phase, or to the operation having been carried out at too low a level. It was necessary to perform sympathectomy in the upper arm for lesions limited to the hand, and to operate in the axilla for pain reaching to the elbow. Gosset had recalled Platon's statistics, 9 improvements out of 12 cases, and Turbin, of Moscow, had reported 8 cases, all of which were successful.

2. For the second or central stage, posterior root section or division of the pain tract in the cord itself was needed.

Dr. Leriche emphasized the fact that he firmly believed that resection and end-to-end suture, or blocking the nerve by alcohol injection, should not be resorted to unless peri-arterial sympathectomy had been tried and had failed. He referred to the fact that amputation in these patients was always useless, and failed to cure the pain.

He reported his results in 20 cases of heterogenous nerve-grafts, based on Nageotte's experimental work: 3 cases of early operation during the war under ideal conditions, and 17 cases of late operation after old war wounds. The results were unsatisfactory on the whole. One early case yielded a fairly

good result, one was not traced, and one failed, after showing early evidence of improvement. In the later operation series, of 7 patients examined two to three years later, only 1 showed improvement. He referred to some of the possible causes of failure, and related how in one patient a histological examination of the graft was made possible, as amputation was performed some two years after the grafting operation. No new axons had been able to reach the graft, as a fibrous-tissue block occurred about the proximal end at the junction of graft and nerve. He considered that autogenous grafts were preferable, and that heterogenous grafts should no longer be employed.

Dr. Leriche next discussed the treatment of trophic disturbances, and strongly urged that the operation of peri-arterial sympathectomy should be given an extended trial. In his hands the results had been favourable whether the operation was performed alone or combined with a resection of the neuroma and a graft. The operation failed in very severe and advanced cases. For these, amputation was needed, and he discussed the question of the level at which such amputations should be carried out.

In conclusion he considered the question of the means whereby the results of the surgery of peripheral nerve injuries could be improved. As the most important factors, he mentioned early intervention, and the greatest possible attention to the nutrition of the paralysed or affected limb. Once again he suggested the operation of peri-arterial stripping, as an adjunct to prevent or diminish contractures and tissue change. "Operation on the sympathetic is in every way a valuable method, to be studied and used as an additional measure in operations on peripheral nerves."

Mr. Archibald Young, of Glasgow, said that his remarks were primarily based on a series of 125 operations on nerves during the period 1914 to 1919, but that he had been interested in this subject since his earliest communication, made at the time of the South African War. Of these 125 operations, 59 were neurectomies (resection and suture) and 66 neurolyses.

Young discussed the technique of suture, and expressed the view that the finest catgut was the best material. He regarded the use of non-absorbable material such as silk as unjustifiable. He discussed the value of protecting the nerve junction after suture by a sheath, and for this purpose had carefully recorded and analysed the results in his own series of operations. In his opinion, the use of an efficient sheath improved the result, and he considered a sheath of fatty tissue obtained from the operation area, or excised through a separate incision from the chest wall, the most satisfactory for this purpose.

Young contrasted the results in war surgery and in civil practice, and he thought that the disturbing effects of persistent and continuous scarring, rather than the complication of sepsis in the wound at or after suture, accounted for the poor results in the war cases.

He gave his own results of autogenous grafting operations in 8 cases, viz.: median, 3 cases, partial recovery in 2; ulnar, 2 cases, result unknown in 1 and uncertain in the other; musculospiral, 3 cases, recovery in 2 and failure in 1.

SUMMARY OF THE DISCUSSION.

It will be seen that, with a few exceptions, the conclusions formulated by the American and Continental surgeons differ very little from those of the British surgeons which are embodied in the preceding report of the writers. The experience of the American surgeons, indeed, as presented by Frazier, forms an exact parallel to our own. The reporters were unanimous on certain points, such as the need for the segregation of these patients under the care of surgeons experienced in this branch of surgery, and under conditions where prolonged and careful post-operative treatment can be carried out. In this connection, those British surgeons who took part on a large scale in the peripheral nerve surgery of the war period are not unmindful of the great debt they owe to Sir Robert Jones for the organization he created, and for his personal leadership.

The advantages of early operation were emphasized by all, and there was general agreement that resection and end-to-end suture was the operation of choice in every case of nerve injury where the nerve was divided or badly damaged.

If direct end-to-end suture was not possible, the American and British surgeons supported the two-stage operation, whilst the Continental surgeons utilized one or other of the various methods of grafting to bridge the gap. They preferred if possible the autogenous graft, but placed more reliance on the results of this method than we believe is warranted by the statistics quoted.

Certain familiar points in technique were raised during the discussion, e.g., the wrapping of fat or fascia round the suture line; but on the whole the opinion was definitely against the retention of this procedure. It was generally felt that if the nerve bed was not satisfactory, transposition into a new intramuscular bed was all that was needed.

A stimulating atmosphere was introduced into the discussion by the vivid contribution of Leriche, in which he strongly urged the more general adoption of his operation of peri-arterial sympathectomy. He insisted on its value in dealing with causalgia, trophic changes, and in fact in all cases with signs of nerve irritation. The operation has not been extensively practised in this country, and, as far as we can judge from the few results known, it has not been highly successful. Whether or not it will take the prominent place in this branch of surgery that Leriche and his followers believe it should occupy, time alone can show. The inherent objection to the rationale of the operation at the present time is its lack of sound anatomical basis. For whilst much remains to be worked out concerning the distribution of the sympathetic fibres in the limbs, it is quite certain that the mass of these fibres do not form a continuous chain localized to the sheath of the main artery over the whole of its course.

On the whole, it was felt that the results of nerve suture in the case of war wounds were disappointing. In many instances, however, it has been encouraging to find that they tended to improve after long intervals. Infection was the outstanding factor in the production of failures, and for this reason the prognosis in the nerve injuries occurring in civil life must always be markedly better.

BIBLIOGRAPHY AND REFERENCES.

General.

Weir Mitchell, Morehouse, and Keen, *Gunshot Wounds and other Injuries of Nerves*, Philadelphia, 1864.

Sherren, *Injuries of Nerves*, London, 1908.

Tinel, *Nerve Wounds*, London, 1917.

Medical Supplement, " Review of German War Literature to 1917 ", Oct. 1, 1918.

Benisty, *Les Lésions des Nerfs*, Paris, 1919.

Head, *Studies in Neurology*, 1920.

Souttar, *Injuries of the Peripheral Nerves*, Bristol, John Wright & Sons Ltd., 1920.

Medical Research Council Report, No. 54, 1920.

Jones, Sir Robert, and others, *Orthopædic Surgery of Injuries*, Oxford, 1921.

Platt, *The Surgery of the Peripheral Nerve Injuries of Warfare*, Bristol, John Wright & Sons Ltd., 1921.

Thorburn, W., *Keen's Surgery*, Vol. vii, Philadelphia, 1921.

Stiles and Forrester-Brown, *Injuries of Peripheral Nerves*, Oxford Med. Publications, 1922.

Stookey, *The Mechanical and Surgical Treatment of Peripheral Nerves*, Philadelphia, 1922.

Special.

[1] Stopford, *Brit. Jour. Surg.*, 1922, Oct.

[2] Sargent and Greenfield, *Brit. Med. Jour.*, 1920, Sept. 25.

[3] Wood-Jones, in the *Orthopædic Surgery of Injuries*, Oxford, 1921.

[4] Kennedy, *Lancet*, 1919, July 5.

[5] Stopford, *Brain*, 1920, May.

[6] Forrester-Brown, *Brit. Med. Jour.*, 1920, Sept. 25.

[7] Sargent, Percy, *Brain*, xliv, Part 2, 1921.

[8] Joyce, *Brit. Jour. Surg.*, 1919, Jan.

[9] Stookey, *Surg. Gynecol. and Obst.*, 1919, Sept.

[10] Leriche, *Presse méd.*, 1916, April 20.

TEMPORARY EXTRA-ABDOMINAL INTESTINAL ANASTOMOSIS THROUGH A TUBE.

By D. P. D. WILKIE, Edinburgh.

The question of effecting a short-circuit of an obstruction of the intestine by means of a tube leading from the distended bowel above to the empty intestine below is one which, so far as I can gather, has received little attention from surgeons. The possibility of such an arrangement being able to function was unknown to me until, almost by accident, it was tried with complete and striking success. The indications for the use of such a device will probably be limited to cases such as the one described below, where obstruction supervenes in a case of diffuse or generalized peritonitis and where the condition of the patient precludes the performance of any major abdominal operation for its relief. The following particulars are from the notes of the case in which this procedure was tried successfully.

Case.—Mr. C., age 38. On May 28, 1922, the patient felt out of sorts in the morning, but was able to go to a cricket match in the afternoon. On the following day he had several severe spasms of abdominal pain and felt sick, but did not vomit. When seen by his doctor on the evening of May 29 he was suffering from colicky abdominal pain. His pulse and temperature were normal, and with the diagnosis of a chill he was given a dose of castor oil. Thereafter the colicky pain became more acute, and at 1.0 a.m. the following day his doctor was again called and found him looking very ill. There was now very marked tenderness and rigidity of the lower abdomen; acute appendicitis was diagnosed and he was removed to a nursing home for operation.

Previous History.—When a youth he had an illness suggestive of appendicitis and had noted occasional pains in the lower abdomen at intervals since then. He also suffered from aortic stenosis and incompetence, and had a very much hypertrophied heart.

Operation, 3.0 a.m. May 30.—Gridiron incision in right iliac region. Seropurulent exudate with fæculent smell escaped. An appendix, which was partly gangrenous and had perforated near its base, where a concretion was tightly impacted in a stenosed area, was removed. The appendix contained dark fluid fæcal matter, some of which had escaped through the perforation. A rubber drain was left in leading to the pelvis.

The patient took the anæsthetic (ether) very badly. He developed a pale cyanotic tinge, and on two occasions stopped breathing. During the first four days after the operation he became progressively more pinched and ill in appearance, with a clammy skin and a constant hiccup. The abdomen was tense and distended. His pulse remained slow (68) and he did not vomit. On the fourth day his condition appeared desperate. His hands and face were cold and clammy, his eyes sunken, yet his pulse remained slow. A stomach tube was passed and 8 pints of orange-coloured foul-smelling fluid

were withdrawn. On the supposition that he had an acute duodenal ileus, the stomach tube was left in, he was turned on his face, and the foot of the bed was raised. This, however, effected no improvement, and repeated washing out of the stomach always brought away large quantities of foul-smelling yellow fluid. It was decided therefore that the obstruction must be below the duodenum, and on the morning of the fifth day after operation the abdomen was opened to the left of the umbilicus under local anæsthesia. A gas-filled coil of small intestine presented, and into this a rubber tube was

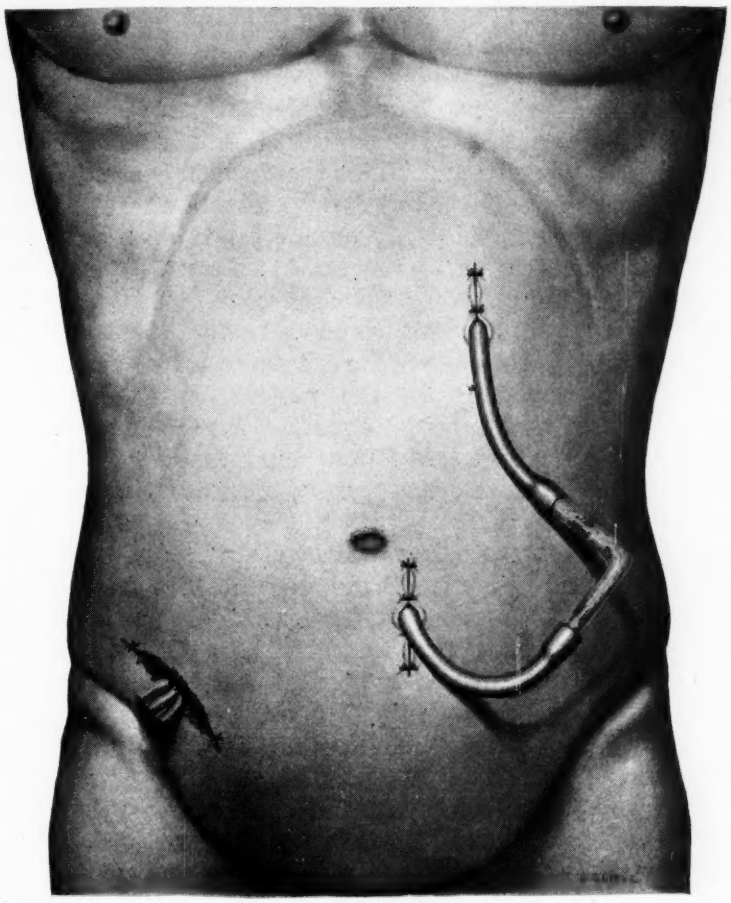


FIG. 321.—Upper tube draining first coil of jejunum connected up with lower tube entering coil of small intestine below the obstruction. A constant stream of content passed through this circuit for five days.

fixed after Witzel's method. Some gas, but practically no intestinal content, came away, but large quantities of glucose solution and peptonized milk were given through the tube. The stomach tube still brought away a great amount of fæculent material, and it was clear that the enterostomy had been made below the seat of the obstruction. During the succeeding eight hours the patient sank perceptibly and was obviously dying from obstruction. Therefore at 8.0 p.m. on the same day a further attempt to relieve him was made.

Under local anæsthesia an incision was made in the epigastrium through the outer border of the left rectus muscle. To make certain of being above the obstruction the highest coil of jejenum was sought for, identified, and pulled up to just below the abdominal wound. A rubber tube was inserted into this after the method of Witzel, and immediately there was a copious escape of fœtid yellow fluid exactly like that which the stomach tube brought away from the stomach.

Over-night and throughout the next day there was an almost continuous stream of fluid content through the tube, and in spite of the fact that fluid nourishment was being given at three-hourly intervals through the lower tube, the patient was emaciating at an alarming rate. There was still regurgitation from the stomach, which was washed out twice daily.

One was now faced with the fact that the patient was threatened with a physiological death from loss of duodenal secretion. To obviate this an attempt was made to preserve and utilize the duodenal secretions by injecting the fluid nourishment into the first jejunal coil and the duodenum through the upper tube and then immediately connecting the latter by means of an L-shaped glass connecting-tube to the lower rubber tube (*Fig.* 321). This was found to work admirably, for the distended upper bowel immediately emptied itself through the rubber tube into the intestine below. This manœuvre carried out two-hourly was followed by an immediate and most remarkable improvement in the patient's general condition. The glazing of the skin and the stuporose condition into which he had sunk both changed with notable rapidity, and he expressed himself as going to recover. For another forty-eight hours, however, the stomach tube was required, as some regurgitation was still going on.

It was now seen that quite independently of the foods given through the upper tube there was an intermittent but rapid flow of intestinal juice going on through the tube, which was obviously functioning as a coil of intestine. Liquid foods were now given by the mouth and could be traced coursing rapidly down through the tube as peristaltic contractions pumped the fluid through.

Thus for five days the artificial intestinal loop functioned. At the end of that time a slight leak occurred at the upper tube, and, as the patient's condition was now good and his bowels had acted on several occasions, it was decided that in all probability peristalsis would now be able to establish intestinal flow by the normal route. Both tubes were now withdrawn and a dose of castor oil was given by the mouth. To our pleasure and surprise there was a copious natural evacuation and very little escape from the jejunal fistulæ. The bowels continued to act normally, the fistulæ closed within two weeks, and the patient rapidly gained in strength and weight, and two months later had resumed his work as a schoolmaster.

This case brought home several points of importance: (1) The necessity for high jejunal drainage in cases of obstruction from peritonitis. (2) The danger from loss of fluid and starvation, with a high fistula. (3) The possibility of tiding a patient over the critical stage by an artificial anastomosis between the obstructed bowel and a coil below the seat or seats of the obstruction, by means of a tube outside the abdominal cavity.

VISITS TO SURGICAL CLINICS AT HOME AND ABROAD.

PROFESSOR THORKILD ROVSING AND THE RIGSHOSPITAL AT COPENHAGEN.

THE Rigshospital is the chief University State Hospital of Denmark. Situated in the northern suburb of the capital and occupying an extensive site, it represents one of the most up-to-date and perfect hospitals in the world. It contains over 1000 beds, which are distributed as follows :—

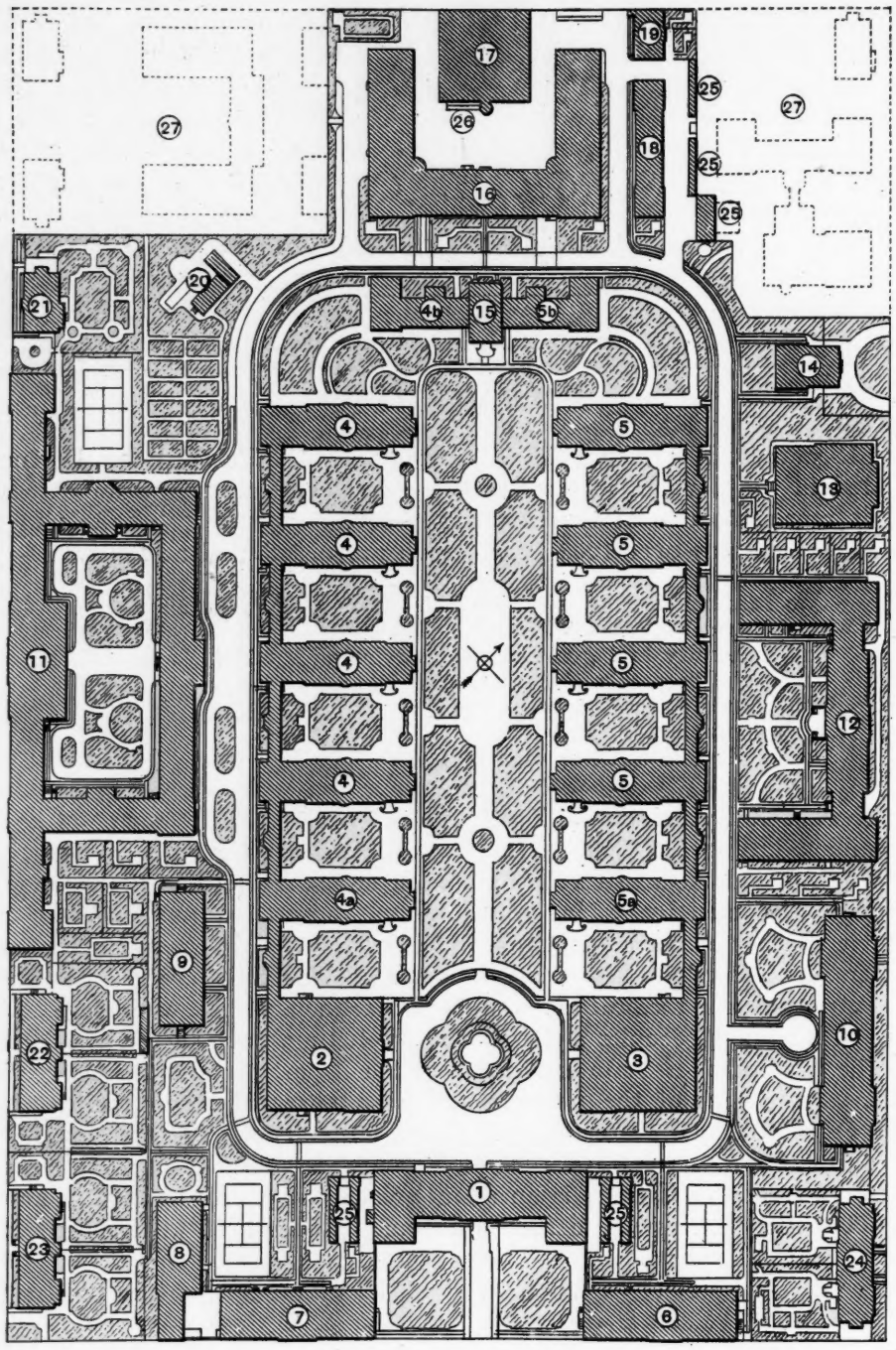
Two medical services with 280 beds
Two surgical services with 280 beds
One maternity and gynæcological service with 283 beds
Children's diseases with 62 beds
Ophthalmic diseases with 20 beds
Aural diseases with 17 beds
Dermatological diseases with 84 beds.

The hospital was built during the years 1905 to 1910 at a cost of nearly ten million kroner (£500,000). It is constructed on the pavilion principle. The surgical and medical services are each accommodated in a series of six buildings connected by a long corridor, and these two groups of buildings face one another across a well-kept garden. The special departments, nurses' quarters, professors' houses, and administrative buildings are grouped round the centrally-placed medical and surgical departments. The whole associated group of buildings occupies a site of 300 by 400 metres. (*Fig.* 322.)

The hospital is a State institution and a department of the University. About 90 per cent of the patients pay a sum towards their maintenance, which costs 13 kroner (10/6) a day. About 50 per cent pay 2 kroner, 33 per cent pay 4 kroner, and 7 per cent pay 12 kroner a day towards this maintenance charge. Thus there is an annual charge of nearly $3\frac{1}{2}$ million kroner (£136,000) representing the deficit of income as compared with expenditure, to be defrayed by the State.

The surgical service of the hospital consists in two departments of equal size (140 beds). Each is under the direction of a professor, who has two assistants and three house surgeons, as well as one pathologist under his direction. The two professors of surgery are Professor Rovsing and Professor Schaldemose.

The wards, arranged on two floors, are much subdivided ; the largest contains only 16 beds, and is subdivided into four parts by a central gangway



GENERAL PLAN OF THE RIGSHOSPITAL.

and by a mahogany partition about eight feet high, so that not more than four patients are associated together in any part (*Fig.* 323).

The operating department (*Fig.* 324) of each surgical service consists of two sets of operation theatres and sterilizing rooms, arranged in series. One theatre contains two tables and the other contains one, so that three operations can be arranged simultaneously. In addition to these operating rooms there is a large well-lighted amphitheatre for demonstration purposes, with terraced seats to accommodate about two hundred students.

On the occasion of a recent three-days' visit, Professor Rovsing began each day by giving us a short lecture in the amphitheatre, and then performed a series of operations. In the afternoon he took us to other departments of the hospital, where we had special demonstrations. In his introductory remarks he described some of the points of general surgical technique.

In regard to general anæsthesia, ether only is used, and it is given by a simple closed inhaler (Wauscher's) consisting of a face-piece and a rubber bag.

DESCRIPTION OF GENERAL PLAN OF THE RIGSHOSPITAL.

1, Administrative block. 2, Surgical theatre. 3, Medical theatre. 4, Surgical pavilions, general wards. 4a, Surgical pavilion, private wards. 4b, Isolation wards. 5, Medical pavilions, general wards. 5a, Medical pavilion, private wards. 5b, Isolation wards. 6, Service of otolaryngology, and polyclinics of surgery and medicine. 7, Service of ophthalmology. 8, Polyclinic of children's diseases. 9, Service of children's diseases, 10, Service of skin diseases. 11, Service of obstetrics and gynæcology. 12, Nurses' quarters. 13, Baths. 14, Chapel. 15, Church. 16, Kitchens and laundry. 17, Central heating furnace. 18, Workshops, stables, service of disinfection. 19, Staff quarters. 20, Greenhouse. 21, House for the Professor of Obstetrics. 22, Houses for the chief accoucheur and one of the chief surgeons. 23, House for the Director and one of the chief surgeons. 24, Houses for the two chiefs of the medical service, 25, Cycle shed. 26, Receptacles for kitchen refuse. 27, Departments of general pathology, pathological anatomy, etc.

The antiseptic methods employed are of special interest, because it was in Rovsing's service that the principles taught by Lister were first most thoroughly applied. Iodine and iodoform are not used at all, because they are regarded as useless and dangerous. Alcohol is now the chief chemical made use of for cleansing purposes, with a phenol compound known as pheno-salyl. Nitrate of silver is extensively used in the form of a gauze, and this is employed over gutta-percha paper for the treatment of burns, and in the packing of deep wounds which require drainage. Formalin vapour is used for the sterilization of catgut and of instruments—for example, cystoscopes and catheters which cannot be boiled.

Another medicament of which Professor Rovsing has made special use is vaseline; this is injected into the joints of patients suffering from dry forms of osteo-arthritis. The first case in which the method was employed was for a lady with congenital dislocation of the hip, now some twenty years ago. It is of special value in senile osteo-arthritis of the hip, where as many as 25 grm. of vaseline are injected by means of a Record syringe, and

the relief of pain which results lasts for as long as ten years, although usually the injections have to be repeated at shorter intervals.

In regard to the employment of drainage tubes, Rovsing makes frequent and varied use of the Pezzer tube. This he ties into the gall-bladder, or into the urinary bladder through a suprapubic opening; and he similarly employs it to drain a pleural empyema when it is attached to a gravity siphon apparatus. In this way he considers that the healing time of empyema has been reduced by 50 per cent. The Pezzer tube is also used for gastrostomy and colostomy.

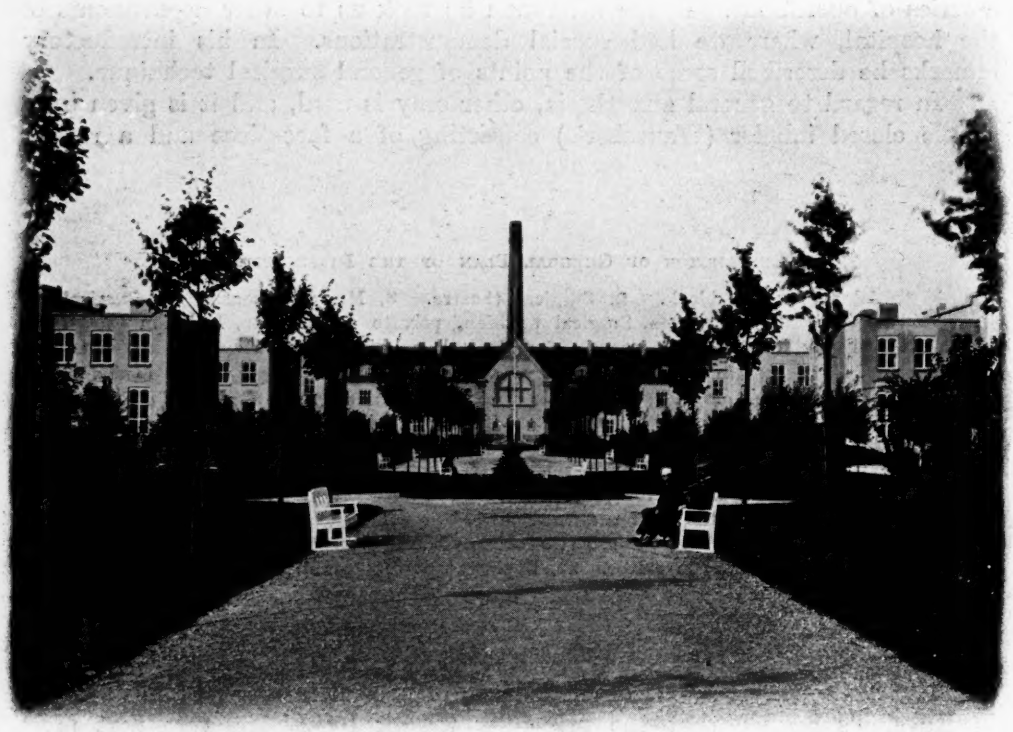


FIG. 322.—View of the exterior of the hospital and grounds.

ŒSOPHAGOPLASTY.

Cases of benign stricture of the gullet seem to be comparatively common in Denmark, where strong caustic alkalis are in everyday use for domestic purposes. Two patients were shown in whom a plastic operation had been done to remedy the occlusion of the œsophagus. One of these was a boy of 12 years, and in his case only the first stage of the procedure had been completed. This consisted in bringing the proximal part of the œsophagus up to the skin, just above the inner end of the left clavicle, and of doing a gastrostomy, the opening of which was near the ensiform cartilage.

The other patient was a woman of 25 who had had the plastic operation completed more than one year previously. After having an œsophagostomy

and a gastrostomy performed, as in the other case, the two openings were connected by a skin tube running down the front of the sternum. This patient drank easily, and the fluid wave could be seen passing down the front of the chest. Her general nutrition is good.

RENAL SURGERY.

Rovsing is an ardent advocate of fixation and decapsulation operations upon the kidneys. He was probably the first to advocate decapsulation for certain types of nephritis, an operation with which Edebohl's name is usually

FIG. 323.—In the wards.

associated. He has done the operation which he calls 'nephrolysis' about 160 times, and is convinced of its value in all forms of nephritis, especially in the 'uratic' types, with attacks of pain and bleeding; here and in many cases of nephrosis full recovery was obtained. In cases of granular nephritis, albumin and blood in the urine diminish and the blood-pressure falls sometimes as much as 100 mm. In regard to fixation operations, he attaches great importance to full restoration of the dropped kidney to its normal position, and he specially deprecates sewing it to the rib; this, he states, is certain to cause pain even when it has not existed previously.

Renal Tumour: Nephrectomy.—(*Operation* 11.55 *to* 12.15.) Female, age 52, who for some time had suffered from severe hæmaturia and had developed a right lumbar swelling. The patient was semi-prone and a transverse incision was made. A large kidney was quickly brought up into the wound. The ureter was ligatured in two places and divided with the cautery. The vessels were ligatured and cut without the use of clamps. A stout cigarette drain consisting of silver nitrate gauze in rubber tissue was put into position. The deep layer of muscles were united by catgut and the aponeurosis by fine aluminium bronze wire.

FIG. 324.—In the theatre.

Nephrolysis for Nephritis.—(*Operation* 12.15 *to* 12.30.) Female, age 38, who had been under medical treatment for albuminuria and hæmaturia for four years. Prone position. Transverse incision. Kidney, which was of moderate size, was brought up into the wound and its capsule stripped. A small piece of the cortex was taken for microscopical examination. The wound was closed, as in the last case, round a cigarette drain. In this case only one kidney was operated upon at a time, but frequently both kidneys are decapsulated at the same operation. Rovsing decapsulates the upper two-thirds of the kidney, and lifts the organ up into normal position by one

silk suture in the remaining part of the capsule of the lower pole, tied over a pad of gauze outside at the height of the tenth rib. This suture is removed after a fortnight.

Renal Exploration for Calculus.—(*Operation* 11.22 *to* 11.50.) Male, age 44, had had repeated attacks of right renal colic. The X rays showed a somewhat doubtful shadow. Position and exposure as in the last two cases. Blood-vessels were twisted with Blunk's hæmostatic forceps. The kidney was small and buried in densely adherent fat. The cortex of the kidney was incised, and through the incision the pelvis was explored with a sinus forceps without result. The case was regarded as one of 'uratic' nephritis, and decapsulation was performed.

ON THE PATHOGENESIS AND TREATMENT OF GALL-STONES.

For many years Rovsing has held original views on the subject of the genesis of gall-stones, and he has continued to advocate these views with his increasing experience. He chose this subject for his probationary lecture more than twenty years ago when he was a candidate for the professorship of surgery; and he kept us keenly interested, if not entirely convinced, as he developed his arguments against the generally accepted theory of Naunyn.

That stasis and infection are not the prime causes of gall-stones he maintains on two broad grounds: first, that neither stasis nor infection is present in the majority of cases when gall-stones exist, and secondly, that stasis and infection may exist for years without producing gall-stones at all. In every one of his 530 cases he made bacteriological examinations of the contents of the gall-bladder. He gives the following list of his gall-stone cases, showing that in the majority the gall-bladder is actually sterile.

Type	No. of Cases	Sterile Cases Per Cent	Infected Cases Per Cent
Solitary stone	84	57	42
Large stone with several faceted stones	20	70	30
Multiple, round	117	62	37
Multiple, faceted ..	247	58	41
Pure black pigment stones	30	60	40
Biliary mud	4	25	75
Mud and stones ..	23	56	43

He thus disposes of the theory that infection is the prime cause of lithiasis. That stasis has nothing to do with it is supported by the fact that patients with gastroptosis and visceroptosis seldom have gall-stones. Moreover, in

infective jaundice both stasis and infection are present, and yet no gall-stones result.

Rovsing drew our attention to the group of pure black pigment stones, composed of bilihumin-chalk, a substance never found in normal bile. These small, prickled, branched concretions, which have been quite neglected by Naunyn and Aschoff as being irrelevant bodies, mostly found in the liver capillaries, are in Rovsing's opinion most important, being the beginning of every gall-stone. This appears from the fact that every gall-stone, round as well as faceted, so-called cholesterin or of mixed composition, if cut through, shows a nucleus of black pigment-chalk (bilihumin), round which the normal ingredients of the bile—cholesterin, bilirubin and biliverdin-chalk—have been deposited. The origin of gall-stones is usually, perhaps always, the precipitation of bilihumin-chalk in the liver cells, caused by a transient intoxication. Having entered the bile capillaries, the bilihumin is modelled in these into small, branched, irregular, black concretions which, owing to their shape, easily become entangled, lumped together, and get impacted in the gall-bladder or the ducts, where they grow by super-addition of cholesterin and bilirubin-chalk.

When the gall-bladder and ducts contain many stones, these are always of the same size, or belong to different 'broods', each 'brood' containing stones of the same size, without intermediate sizes, thus showing that a number of stones must be deposited at once, and he suggests that this is on account of a chemical, transient diathesis in the liver. That gall-stone patients are mostly females and women who have borne children arises from the fact that in pregnancy the liver undergoes some change such as the 'gravidity liver' described by gynæcologists, together with intracellular pigment deposit, the beginning of gall-stones.

Other conditions, such as pneumonia, cancer, and osteomyelitis often precede the deposit of pigmentary gall-stones.

Those who advocate the removal of the gall-bladder as the routine treatment for gall-stones regard the organ (1) as the native home of gall-stones, and (2) as useless, and point to such animals as the horse, which has no gall-bladder, as evidence that this structure is unnecessary. Now the native home of gall-stones is the liver, not the gall-bladder, and although the horse possesses no gall-bladder, he may have gall-stones, so that the removal of the gall-bladder is no guarantee against lithiasis.

Rovsing believes that the gall-bladder is intimately connected with the proper secretion of the hydrochloric acid of the stomach, and that its removal leaves the sphincter of Oddi paralysed, with consequent achylia. In cases of cholecystitis or of gall-stones, therefore, the gall-bladder is never removed, but only drained. The operation of cholecystectomy he reserves for cases of gangrene or cancer.

Cholecystostomy.—(*Operation* 11.0 *to* 11.20.) Female, age 18, who had had two children, the last three months previously. She had severe attacks of colic during pregnancy, and the diagnosis of gall-stones was made. An angled incision was made parallel to the right costal margin and down the middle of the rectus muscle. The rectus was split. The gall-bladder was distended and injected; it was grasped by two forceps and punctured by a

trocar, some thick bile being drawn off into a test-tube for bacteriological examination. The neck of the gall-bladder was held over a Mayo's spoon and the fundus opened, showing a typical 'strawberry' appearance. Thick bile and mucus were removed, but no stone was found. A Pezzer tube was tied in and a silver nitrate cigarette drain packed round the gall-bladder. The wound was closed in layers.

Drainage of Gall-bladder.—(*Operation* 11.55 *to* 12.10.) A woman, age 66, who had had repeated attacks of hepatic colic but no jaundice. The right rectus muscle was split. The gall-bladder was buried in adhesions and was thickened. The same technique was used as in the last case. No gall-stones were found, and the gall-bladder was drained.

ON GASTROPTOSIS AND VISCEROPTOSIS.

Rovsing was one of the pioneers in the field of visceral ptosis, and he remains to-day quite undaunted either by the general experience of disappointment with operative methods or by the variety of different procedures which have been suggested as a radical cure. He showed three patients upon whom he afterwards operated, and while showing them made some general remarks about the conditions of visceroptosis. He has collected from his own experience and from the literature no fewer than 1291 cases which have been treated by gastropexy, with the following results: Cured, 75 per cent; improved, 14 per cent; not benefited, 9 per cent; mortality, 2 per cent.

In 90 per cent of cases the patients are women, and of these there are two types, which he describes as the 'virginal' (nulliparous) and the 'maternal' (parous). In the former the pain is much more severe and less easy to control by external pressure. In the maternal type he always first employs a Curtis belt, and operates only if this fails to give relief. In the diagnosis of the condition, reliance is placed upon the physical signs of the displacement, including, of course, the X-ray appearances, together with the symptoms of pain, vomiting, and constipation, which strongly suggest gastric ulcer but are associated with a diminution of gastric hydrochloric acid. He first operated upon such conditions in 1897, placing a series of transverse sutures in the axis of the stomach, bringing the two ends out through the recti muscles, and tying them over a padded glass plate. Recently, however, he has employed the ligamentum teres in the manner described below. If the colon is also dropped and the gastrocolic omentum stretched, then this latter is reefed up by a series of stitches to the greater curvature of the stomach.

The first patient of this type that we saw was a female, age 26, married but with no children—a typical case of 'virginal' gastroptosis. She began to menstruate at 12, and ever since that time has suffered from dyspepsia, with pain, vomiting, and constipation. The vomit frequently contained blood. The test meal showed normal acid contents. There was no stasis in the stomach. The X rays showed that both stomach and colon were very low in the abdomen, the latter lying in the pelvis. On examination there was a marked depression in the epigastrium, where the aorta could be

seen and felt pulsating. For some years she had been treated for gastric ulcer, and the appendix and right ovary had been removed. By the side of the umbilicus was the mark of a blister which was referred to as the '*carte de visite*' of the physician under whose care she had been for 'hysteria'.

Operation, 11.25 *to* 11.45.—Median incision above the umbilicus. The liver lay with its margin well below the ribs and compressed laterally. The pylorus and duodenum were so mobile that they could easily be lifted out of the abdomen. There were some adhesions of the great omentum in the pelvis. The transverse colon was held up so as to expose the gastrocolic omentum and show its vessels. Three catgut stitches were passed from the first curve of the stomach in and out of the omentum to the anterior longitudinal band of the colon, and tied. The lower end of the ligamentum teres was cut, and the band was then stitched by silk to the lesser curve of the stomach. The free end of the ligament was brought through the left rectus and fixed by a silk suture. The abdomen was closed in three layers.

The second case was a female, age 41, married, with three children. After the first child she began to complain of dyspepsia and constipation. No vomiting. X rays showed ptosis of stomach and colon. The operation subsequently done for this case was identical with that just described.

The last case was a displacement of a quite different type. Male, age 36. At the age of 11 he had had a severe crushing accident, and ever since had been suffering from dyspepsia, with marked vomiting and constipation. Had been diagnosed as a gastric ulcer, but the gastric hydrochloric acid was normal. The X rays showed that he had a large diaphragmatic hernia on the left side in which was a large part of the stomach and colon, extending as high as the level of the second rib.

Operation, 11.50 *to* 12.35.—Mid-line incision above the umbilicus. Most of the small gut was drawn out of the abdomen and wrapped in hot towels. The liver was large and lay low in the abdomen. The omentum was very adherent to the opening in the diaphragm. It was ligatured and divided in several places. The left hand was pressed cautiously through the opening in the diaphragm. The stomach was drawn down, looking dilated and much congested. The colon was pulled down with even greater difficulty. The stomach was stitched by silk stitches to the margin of the liver. The great omentum and transverse colon were stitched to the great curve of the stomach. The ligamentum teres was used as above as an anchor to fix the stomach to the left rectus. No attempt was made to close the opening in the diaphragm. The small intestine was returned to the abdomen with great difficulty. The abdominal wall was closed in three layers.

OPERATIONS BY PROFESSOR SCHALDEMOSE.

Professor Schaldemose, who has charge of one of the surgical services, was good enough to allow us to witness three operations.

The first case was one of cerebral cyst. The patient was a male, age 7, with headache and left facial paralysis and choked discs with three diopters of swelling.

Operation 8.15 *to* 8.30.—The head had been completely shaved. The guiding lines for the right Rolandic area were marked by the pressure of a tight string pressed over the scalp. The flap over the area was surrounded by a looped silk ligature which acted as an efficient hæmostatic. A bone-flap was formed by means of four burr openings connected by a revolving osteotome. These were worked by a powerful overhead motor. The dura was divided by a crucial incision, and as it was cut a large quantity of thick dark fluid escaped from the cyst beneath. The dura and skin were closed by interrupted catgut sutures. The hæmostatic silk stitch was left in place in the skin, but it was cut in four places.

The second case was parenchymatous goitre in a female, age 48, who had had a large goitre for many years; it had caused no symptoms but had become very unsightly. The neck had been infiltrated by ½ per cent novocain, followed by 1 per cent injected over the principal nerves.

Operation 8.30 *to* 8.55.—Collar incision. The goitre affected chiefly the right lobe. The infrahyoid muscles were divided, the tumour was brought up by means of a shoehorn spatula. The vessels were ligatured and divided, and the tumour was removed after cutting through the isthmus. The wound was drained.

In the third case cholecystectomy was performed for gall-stones in a male, age 50, who had had three attacks of colic. Oblique incision made below the right costal margin. The gall-bladder was much enlarged and adherent. It was first separated from the omentum and then from its bed in the liver. The cystic duct and artery were clamped and divided. The gall-bladder was thickened, and measured about 3 by 1 in. and was filled with a number of gall-stones. The common duct was probed through the cut end of the cystic duct, but nothing further was found. A drainage tube was passed into the common duct and a second drain was placed in the peritoneal cavity. The wound was closed in four layers.

SOME OF THE SPECIAL DEPARTMENTS OF THE HOSPITAL.

It is impossible in the space at our disposal to do justice to the many highly specialized departments of the hospital, but we were much impressed by their splendid arrangement, and still more by the enthusiasm of those in charge of them. One of the most notable departments is the Finsen Institute, where the work of this great scientific observer is still carried on with increasing success. Dr. Chievitz showed us the kind of work which is being done here for tuberculous joints. Every case of tuberculous disease is treated by the Municipality. Suitable early cases of bone and joint disease get the general light bath given three times a week for two and a half hours at a time. It was a remarkable sight to see these nude patients in groups of four or five roasting themselves round three huge carbon arc lights, their eyes shaded by dark glasses, their skins deeply bronzed and pouring with perspiration. There are 80 in-patients in the light department, and a daily attendance of about 150. The treatment is continued for two to four years, and all cases are followed up for several years later.

Good results were shown in tuberculous ankles, elbows, shoulders, and

knees in children, but it was remarkable that no splints were used except for the temporary relief of pain.

Dr. Fibiger, who is in charge of the Pathologico-anatomical Institute, gave a most interesting demonstration of the artificial production of cancer in rats and mice, the stomach cancer in rats caused by a nematode worm, and the tar cancer in mice.

Dr. Fischer in the Institute of General Pathology demonstrated the culture of epithelial and connective tissue *in vitro*.

It is impossible to close this brief account of a visit to Professor Rovsing at the Rigshospital without expressing admiration for the organization, equipment, and personnel of this great State Hospital. The enthusiastic and cordial co-operation of so many workers in the task of scientific healing was most impressive. Our special thanks are due to Professor Rovsing and his colleagues, and also to the Director of the Hospital, M. Olgaard, all of whom lavished upon us information, kindness, and hospitality.

SHORT NOTES OF RARE OR OBSCURE CASES.

MALIGNANT PAPILLOMA OF RENAL PELVIS ASSOCIATED WITH CALCULUS.

By GEOFFREY HADFIELD, Bristol.

Malignant new growth of the renal pelvis is an uncommon tumour, and of the 54 recorded cases calculus was found in only 10.[1] The pathological changes accompanying calculous pyelitis would seem, from analogy with those found in cholelithiasis, to predispose strongly to malignancy, and the apparent rarity of this complication is all the more striking in the light of the fact that the continued presence of a calculus in the renal pelvis may cause leukoplakia of its epithelium.[2]

A woman, age 48, was admitted to the General Hospital, Bristol, complaining of pain in the back and a lump in the abdomen. Fourteen years before admission she had an attack of painless hæmaturia lasting several days. She enjoyed fair health and freedom from hæmaturia for thirteen years after this; then she had another attack of hæmaturia lasting four weeks and accompanied by lumbago pains "right across the back". These symptoms gradually subsided, and she was free from trouble for twelve months, i.e,. until a fortnight before admission, when, following a slight knock on the left side, she had an attack of acute lumbar pain and vomiting, followed the next day by profuse hæmaturia. On admission, the hæmaturia was subsiding.

Condition on Admission.—A painless hard tumour the size of a fist was found in the left hypochondrium, moving slightly with respiration. The upper border was 1½ in. below the costal margin, and a hand could be passed up between the tumour and the lower ribs. No kidney could be palpated on the left side in the normal area. The right kidney was not felt. The urine was faintly acid and turbid. The deposit was purulent and blood-stained. No crystals, casts, or epithelium were found. Many red blood-cells and leucocytes were present. A pure growth of *Bacillus coli* was obtained on culture.

The kidney was excised, the ureter being tied off just below its lower pole. The wound healed, but twelve days after the operation broke down, firm union finally following after three weeks' suppuration.

Two and a half years after this operation the patient was readmitted for persistent discharge from the wound, and an irregular painless mass was palpated from the abdomen in the position of the excised kidney. The urine was blood-free but purulent, and gave a heavy growth of *Bacillus coli.*

The abdomen was opened, and a large mass of growth found: it was firmly attached to the posterior abdominal wall and adherent to the descending and transverse colon. It was considered inoperable. The patient died a few months after this operation; no post-mortem examination was performed.

Pathological Report on Kidney.—The renal pelvis and calices are greatly dilated by blood-stained fluid, and the kidney tissue is reduced to a shell about $\frac{1}{2}$ in. thick. The wall of the pelvis is greatly thickened but quite smooth. Lying at the lower pole of the kidney, in the position of its lowermost dilated calices, is a large tumour mass roughly spherical in shape and $2\frac{1}{4}$ in. diameter, in the centre of which lies a spherical mulberry calculus $\frac{3}{4}$ in. diameter. The tumour appears to have grown around the calculus as a nucleus, and extends chiefly backwards and inwards, infiltrating the lower pole of the kidney. It bulges the pelvis from below, but has not infiltrated its wall except at the uretero-pelvic junction, where the pelvis and ureter are lost in the growth. The free edges of the tumour and of the cavity in which the calculus lies are beset by innumerable, small, vascular, papillary fringes. The centre of the tumour is white and firm, and on section is seen to be intersected by faintly-indicated branching bands of translucent fibrous tissue from which spring closely-set papillary masses of growth. This pattern on section is lost in the posterior part of the tumour, where it has pierced the lining of the contained calices: here it is homogeneous, firm and white, and an incomplete capsule of muscle and fascia covers it externally. The tumour appears to have originated in the lowermost calices of a hydronephrotic kidney, around a calculus, has infiltrated the lower pole of the kidney and the adjacent perinephritic tissue, and has completely occluded the upper few inches of the ureter. (*Fig.* 325.)

Fig. 325.—Malignant papilloma of renal pelvis. ($\frac{2}{3}$ nat. size.)

The microscopic structure varies considerably in different parts. Posteriorly, where the tumour has infiltrated and destroyed the kidney, its characters are those of a rapidly-growing spheroidal-celled carcinoma, except

that here and there some cell groups show a moderate degree of central keratinization. Towards its periphery, and especially where the edge of the growth lies free in the distended calix, the structure is that of a simple papilloma, except that there is considerable irregularity in, and nuclear hyperchromatism of, the cells. (*Figs.* 326, 327.)

Sections did not show any renal metastases at a distance from the tumour, and there were no active inflammatory changes in the wall of the pelvis. No sign of pelvic leukoplakia was found.

FIG. 326.—Low-power view, showing inflation of the wall of the dilated calix of the kidney.

Miller and Herbst have collected 54 cases of papillary epithelioma of the renal pelvis, and remark that of a series of 70 consecutive tumours of the kidney 2 only occurred in the pelvis.[1] In their 54 collected cases of papillary epithelioma, 10 were associated with calculus and 3 with infection. The growth varies from multiple bud-like isolated nodules to a single cauliflower-like mass distending the pelvis. One bilateral case has been reported[3]. The growths tend to show varying degrees of histological malignancy in different parts.

Ewing[4] describes these tumours as presenting two distinct types: (1) simple papillary epithelioma suggesting a relation to benign papilloma, and (2) squamous-celled carcinoma. Intermediate types have been described. The more pronounced papillary growths tend to invade the ureter and appear at the ureteric orifice of the bladder.

The majority are diagnosed in patients between the ages of 50 and 60.

Intermittent hæmaturia is often found. Colic may be present from ureteric clots, but pain is not common. The hæmaturia is early (in one case four years, and in another seven years, before the condition was diagnosed). A palpable tumour was present in about one-third of the cases.[3]

The case reported here is apparently a transition type between papillary epithelioma and squamous-celled carcinoma. The absence of growth in the

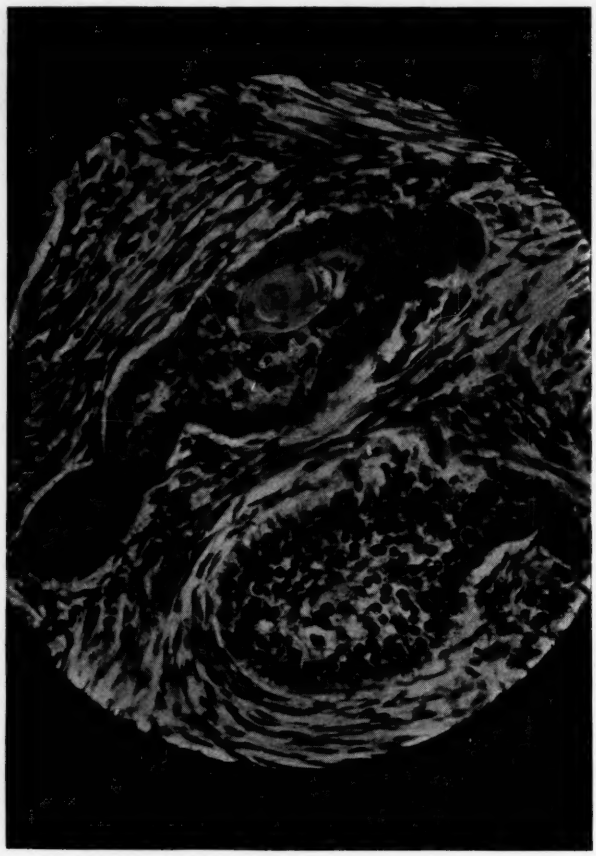


FIG. 327.—High-power view, showing keratinization of cell masses of the growth.

renal pelvis proper, with a growth of the dimensions described in the calices of the kidney, was striking. The great variability in histological malignancy and the slight but definite tendency of the cell masses to keratinize were the most salient pathological features of the tumour.

I am indebted to Mr. R. G. P. Lansdown, Surgeon to the General Hospital, Bristol, for permission to publish the case.

REFERENCES.

[1] MILLER, E. M., and HERBST, R. H., *Jour. Amer. Med. Assoc.*, 1921, lxxvi, April.
[2] MCCOWN, *Jour. Amer. Med. Assoc.* 1920, lxxv, 1190.
[3] MURCHISON, *Trans. Pathol. Soc. Lond.*. 1870, xxxi. 353.
[4] EWING, *Neoplastic Diseases*, 1919, W. B. Saunders Co., 742–5.

TWO CASES OF FATAL HÆMATEMESIS OCCURRING AFTER SPLENECTOMY FOR BANTI'S DISEASE.

By DUNCAN WOOD, Bristol, and C. S. GIDEON, Bath.

The cases forming the subject of this report occurred at the Ministry of Pensions Hospital, Bath, and are reported with the kind permission of the Ministry of Pensions, and of Professor Hey Groves, to whose ward *Case* 1 was admitted.

Case 1.—Well-nourished man, age 32. Pale, with a chlorotic appearance. In 1916, while in the Army, he was found to be suffering from splenic anæmia. The spleen and liver were then noted to be enlarged, being 2½ in. and 1½ in. respectively below the costal margins. There was no previous history of hæmatemesis. He was discharged from the Army on July 10, 1917, as permanently unfit with splenic anæmia, which was recorded as attributable to service and exposure in the war.

Splenectomy was performed by Sir Hugh Rigby at the London Hospital on Dec. 12, 1917. The spleen weighed 1 lb. 15 oz. He made satisfactory progress after the operation, and his condition occasioned no comment until March 22, 1921, when he complained of abdominal discomfort, followed, in a couple of hours, by fainting. Severe hæmatemesis occurred seven hours later.

He was admitted to the Pensions Hospital the following day, March 23, when he again vomited 2½ pints of dark clotted blood.

A blood-count on April 1 showed :—

Hæmoglobin, 48 per cent	Lymphocytes, 38 per cent
Colour index, 0·96	Large mononuclears, 10 per cent
Red blood-corpuscles, 2,500,000	Basophils, 1 per cent
White blood-corpuscles, 8800	Eosinophils, 1 per cent
Polymorphs, 50 per cent	

The red cells showed some variation in shape, but more in size, being mostly megalocytic. There was some polychromatophilia and granular basophilia. There were 55 normoblasts and 5 megaloblasts in 300 leucocytes.

A later blood-count on August 10 showed :—

Hæmoglobin, 90 per cent	Red blood-corpuscles, 4,700,000
Colour index, 0·95	White blood-corpuscles, 7600

After three free intervals of ten, four, and seven months respectively, hæmatemesis recurred. On the last occasion he vomited about 6 pints of blood within thirty-seven hours, and then collapsed and died, on Jan. 30, 1923. On admission on the last occasion his temperature was 100°, and it kept above normal until just before death.

In December, 1922, a blood-count showed :—

Hæmoglobin, 64 per cent	Lymphocytes, 54·5 per cent, mostly of large type
Colour index, 0·82	Large mononuclears, 10 per cent
Red blood-corpuscles, 4,300,000	Basophils, 1 per cent
White blood-corpuscles, 5400	Eosinophils, 0·0 per cent
Polymorphs, 32·5 per cent	

Post-mortem Findings :—

Stomach.—Very enlarged, filled with fluid and clotted blood. No ulceration of stomach. No dilatation of vasa brevia veins.

Œsophagus.—Marked varicosity of veins around lower part of œsophagus, with a large ruptured vein near cardiac end of stomach, a clot partly filling its lumen.

Spleen.—This was absent, and its space occupied with omentum and fat, which was very adherent to the diaphragm. No accessory spleens.

Liver.—Marked multilobular cirrhosis. Other organs pale but normal. Small and large intestine filled with melæna.

Case 2.—Regular soldier, age 30. In October, 1915, he was buried by the explosion of a shell, and suffered from hæmatemesis for two days. Off and on after this he had slight attacks of hæmatemesis, and was discharged from the Army on Dec. 17, 1917, with an enlarged spleen and disorderly action of the heart. Between this date and his admission to hospital on Sept. 7, 1920, for severe hæmatemesis, he suffered much from pain in the left side of the abdomen and epistaxis on stooping.

On admission, his general condition was fair. Pulse 110. There was no ascites or enlargement of the liver. The spleen was found much enlarged. Blood-count :—

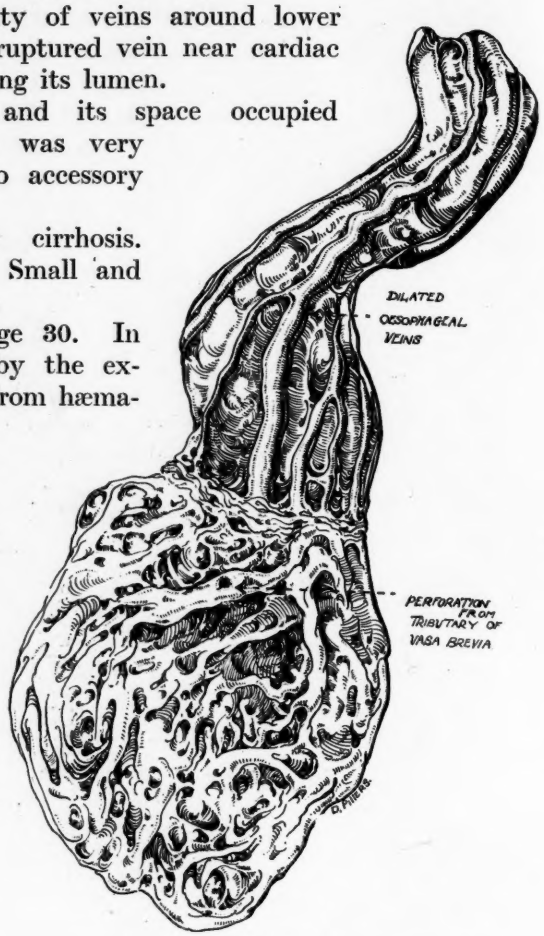


Fig. 328.—*Case* 2. Showing site of perforation of dilated vasa brevia vein through gastric mucous membrane.

Hæmoglobin, 50 per cent	Large lymphocytes, 10 per cent
Colour index, 0·5	Small lymphocytes, 15 per cent
Red blood-corpuscles, 4,560,000	Transitionals, 3·4 per cent
White blood-corpuscles, 4700	Eosinophils, 1 per cent
Polymorphs, 68 per cent	

Splenectomy was performed by Mr. Duncan Wood on Oct. 16. A vertical incision was made along the outer border of the left rectus abdominis. The spleen was not adherent. On breaking down the lieno-phrenic ligament the spleen could be displaced outside the abdominal wall and was held there by gauze packed in behind. The gastrosplenic omentum was then tied. The pancreas was not adherent. The spleen was turned forwards and the lieno-renal ligament tied. Bleeding was very slight during these manipulations. Left lobar pneumonia complicated his recovery.

There was marked improvement in the man's condition, and a blood examination on Dec. 10 showed :—

Hæmoglobin, 70 per cent	Polymorphs, 52 per cent
Colour index, 0·7 per cent	Lymphocytes, 30 per cent
Red blood-corpuscles, 5,000,000	Large mononuclears, 14 per cent
White blood-corpuscles, 20,000	Eosinophils, 3 per cent

At 9 a.m. on June 16, 1921, he had an attack of hæmatemesis, following one month's feeling of general indisposition, and was admitted to hospital.

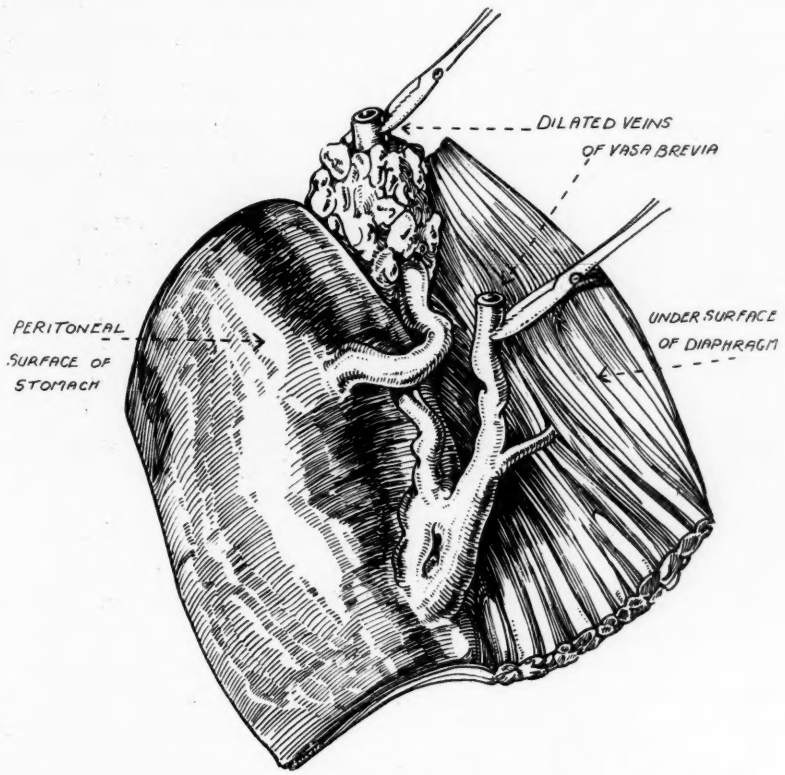


FIG. 329.—*Case* 2. Dissection of peritoneal surface of stomach to show dilated vasa brevia veins.

He gave the history of having vomited about half a pint of unclotted blood. He showed no signs of collapse. Temperature 99°. Pulse 120. He was treated with subcutaneous injection of 10 c.c. horse serum and morphia hypodermically. Twenty-four hours after this attack, he vomited 1½ pints of blood, light-red in colour, with few clots. This was followed by two severe attacks of hæmatemesis on June 19, when he died.

POST-MORTEM FINDINGS :—

Stomach.—Much dilated and full of fluid and clotted blood. A large open varix was found 1½ in. below the œsophageal opening at the cardiac end (*Fig.* 328). The vasa brevia veins were enormously dilated, as is well shown in *Fig.* 329.

Œsophagus.—Large varices around its lower end.

Liver.—Smaller than usual. Multilobular cirrhosis.
Spleen.—Absent. No accessory spleens.

The above cases are of interest for the following reasons :—

1. The time of the occurrence of the hæmatemesis in the two cases: *Case* 1 had no hæmatemesis before the operation, and first suffered from this three and a quarter years after splenectomy; *Case* 2 suffered both before and after the operation from hæmatemesis.

2. Death occurring in *Case* 1 five years and one month, and in *Case* 2 eight months, after splenectomy—in both cases after an improvement in their condition had been noted.

3. The diagnosis of the cause of the hæmatemesis in these cases, and the futility of an operation. In this connection it is interesting to note that both the above cases gave a temperature above normal following severe hæmatemesis.

4. *Case* 2 presents all the features of recorded cases by Ledingham and Moynihan of splenic anæmia following severe abdominal injury.

5. The question arises whether in these cases the removal of the spleen either prevents or retards cirrhotic changes in the liver.

CAST OF STOMACH FORMED BY A MASS OF FOREIGN BODIES: PERFORATION.

By C. JENNINGS MARSHALL, London.

A. M., a woman of 22, was seen at King's College Hospital on June 23, 1921. Twelve hours previously, during the night, she began to suffer from severe pain in the upper part of the abdomen near the ribs on the left. Vomiting was stated to be 'incessant'; this was very doubtful, as during the two hours under observation before operation she was observed to retch only a few times. The bowels had been open that morning. It was impossible to get a clear account of the preceding history. The patient was of very dulled mentality: the relatives stated she had had influenza six months before, and that for two months after this she had been queer, did not seem to know where she was, and had no memory of the period. Four months ago—at the end of this illness—she had been admitted to hospital under the suspicion of appendicitis, but no operation had been performed. Both before and after this admission she had suffered from indigestion and frequent vomiting after food. Blood had not been brought up. The appetite was good, but little food could be taken on account of the pain.

The patient seemed in great pain, and sat and walked with the trunk flexed. Hiccup and very occasional retching were observed. The pulse was 88, the temperature 97·2°. Two hours later these were respectively 104 and 98·8°. The tongue was heavily furred, the palatal reflex absent. The abdominal wall was held absolutely rigid in the upper part; in the lower the muscles contracted strongly in expiration. Extreme and universal tenderness,

expressed by moaning and some shrieking on the lightest palpation; disappeared on distracting the attention, with the exception of invariable boarding of the upper recti. Apart from a large tympanitic swelling in the right iliac fossa, unaccompanied by any other sign there, no further physical sign was made out. An enema produced a small hard mass of fæces. There seemed to be an acute organic basis for the hysterical condition—possibly a slowly-leaking gastric ulcer.

Right paramedian laparotomy revealed a normal appendix and a cæcum distended to the size of a fist. As the colon was traced onwards, this distention disappeared without any obstructive cause being revealed. In the middle of the transverse colon a hairpin was found, one end embedded in the

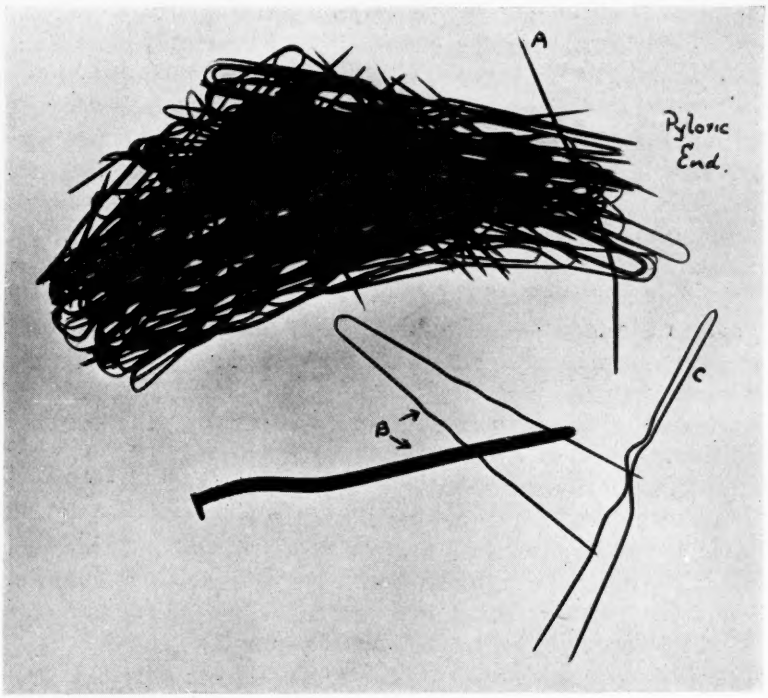


FIG. 330.—Radiogram of mass. A, Needle perforating stomach; B, Nail and hairpin detached during removal; C, Hairpin removed from transverse colon.

mucosa; it was removed through a small incision. The distal half of the stomach was contracted and hard, and evidently occupied by an irregular mass. Projecting about an inch through the anterior surface about 1½ in. below the lesser curve appeared a sharp stout needle, the other end emerging through the posterior wall just below the lesser curve. The two perforations, after withdrawal of the needle, were seen to be blackened and to be surrounded by a localized plastic peritonitis. There was no leakage of gastric juice, no free fluid. The posterior wall was over-sewn. After packing off, removal of the mass was attempted by an incision across its middle at right angles to the long axis of the stomach. So embedded, however, was its surface in the mucosa that a further cut had to be added, converting the gastrotomy into

an L shape. The stomach was then peeled off it. A raw, coarsely granular surface was left, oozing freely. A strip was removed for microscopy. The opening was closed in the usual way, a few ounces of 1-1000 acriflavine were poured into the abdomen, and this was closed after ascertaining as far as possible that there were no further foreign bodies in the viscera.

Convalescence was smooth. At the end of a week fish and chicken were eaten without discomfort.

A bismuth meal at the end of three weeks showed normal emptying of the stomach, with a little rigidity and narrowing of the distal part. A needle was seen at the right side of the 1st lumbar vertebra, but as it had been impalpable in the corresponding part of the bowel, it was concluded that it was retroperitoneal and need not be removed. Seen later, the patient was in complete health; she had become normal mentally, but still had no recollection of the ostrich period of her life. Recently she writes: "I have nothing to complain of, and feel perfectly well since my operation".

The intensely foul-smelling mass removed consisted largely of hairpins (*Fig.* 330); but there were also two locket chains, safety-pins, needles of various kinds, and one large nail which became detached from the mass during extraction. The whole was welded together by dark-brown mucus in which could be seen numerous grape skins and seeds. Erosion of the metal was very evident; the points were all extremely sharp, and the bends of the pins thinned, i.e., this occurred where there was contact with the mucosa. The pin lying across the long axis should be ½ in. nearer the centre of the mass; it was removed separately, and was responsible for the perforation. It seemed evident that the mass had remained the same for some considerable time; the degree of adhesion to the mucosa precluded the possibility of any recent addition. This, of course, fitted the history.

The microscope showed intense hyperæmia, great leucocytic infiltration of the submucosa, and intense catarrhal changes.

The case seems to show that trauma alone with superadded sepsis is not capable of initiating gastric ulceration. Here it produced an intense true gastritis—not the casually diagnosed 'explanation' of the majority of indigestions!—which, on removal of the cause, promptly healed.

SUBACUTE PANCREATITIS (ATRESIA OF THE PANCREATIC DUCT?) OCCURRING IN ASSOCIATION WITH ACUTE INTESTINAL OBSTRUCTION IN A NEW-BORN INFANT.

By T. TWISTINGTON HIGGINS, London.

L. N., male, age 16 days, was admitted to the Hospital for Sick Children, Great Ormond Street, on April 26, 1922, under the care of Dr. Robert Hutchison, to whom I am indebted for permission to publish these notes. He was born a 'beautiful baby', but had vomited every feed since birth. The vomiting was forcible, the statement being made that the stomach

contents were pumped 'about a yard'. The bowels were said to have acted during the first two days of life; thereafter they had been obstinately constipated. The baby was always hungry. He was breast-fed.

FAMILY HISTORY.—Father and mother healthy. Three miscarriages (at 6 and 8 weeks). Then followed the first child, now aged 13 months, and healthy. The patient is the second living child.

CONDITION ON ADMISSION.—A rather wasted infant, weighing 6 lb. 8 oz., but otherwise in fairly good condition. Vomiting occurred after every feed taken, profuse, forcible, and stained with bile. After a feed gastric peristalsis could be well seen, but no tumour could be felt. Breast-feeding was continued in small quantities at short intervals, and subcutaneous saline with glucose 2 per cent was administered concurrently. Gastric lavage was instituted daily, and the washings always contained bile.

This treatment was continued for some days, and the baby gained 6 oz. in weight, but otherwise the condition remained unchanged: the vomiting continued unabated, and the gastric contents always contained bile. The baby passed an occasional small brown undigested stool. The case was regarded as one of duodenal obstruction.

A radiographic examination was conducted by Dr. Bertram Shires, who reported as follows:—

> The opaque meal was seen to pass into the stomach normally. In a few minutes active peristalsis was observed, with no passage of food through the duodenum. In 20 minutes practically no food had left the stomach. In 45 minutes traces of the meal are seen in the small bowel. There is a persistent shadow in the duodenum. In 4½ hours only a quarter of the meal has left the stomach.
>
> There is definite evidence of some obstruction. The pyloric end appears normal, suggesting the obstruction is post-pyloric.

OPERATION, May 2.—A preliminary subcutaneous injection of saline with glucose 2 per cent was administered before operating—1½ oz. into each axilla—and the stomach was washed out one hour before operation. The anæsthetic employed was gas and oxygen. The abdomen was opened by a mid-line incision above the umbilicus. Some free fluid immediately escaped, which was distinctly milky in appearance. The stomach and pylorus appeared normal, but the duodenum was dilated. The jejunum and ileum were collapsed and empty. The colon was of normal size, but the walls appeared very thin and yellowish in colour.

There was evidently some obstruction localized at or about the duodenojejunal junction, and on further investigation in this region a very remarkable condition of affairs was revealed.

In the region of the pancreas and the root of the mesentery there was a diffuse, pultaceous-looking mass, greyish-white in colour and firm in consistence. What appeared to be ducts, containing whitish milky-looking fluid, were to be seen coursing over its surface, and there were several yellowish-white patches discernible in the vicinity, dotted over the surface of the mesenteries, rather suggestive of the patches of 'fat necrosis' in acute pancreatitis.

The duodenojejunal flexure was bound up in this mass, and the gut was obstructed at this point. The jejunum came away from this fixed attachment

as though completely twisted on itself, and the distal gut was tiny and quite empty (*Fig.* 331).

It was decided that any attempt to free the gut would be unwise, and accordingly a posterior gastro-enterostomy was performed by the customary method. The abdomen was closed in layers. At the completion of the operation, the baby's condition was very fair, and, despite a few critical days, he rallied well from the somewhat prolonged intra-abdominal procedure. The wound healed aseptically and the stitch was removed on the eighth day. Convalescence, however, was very prolonged and tedious. Vomiting continued for a considerable time, though in diminishing degree, and it was not until June 21 (i.e., seven weeks after operation) that gastric lavage was finally discontinued.

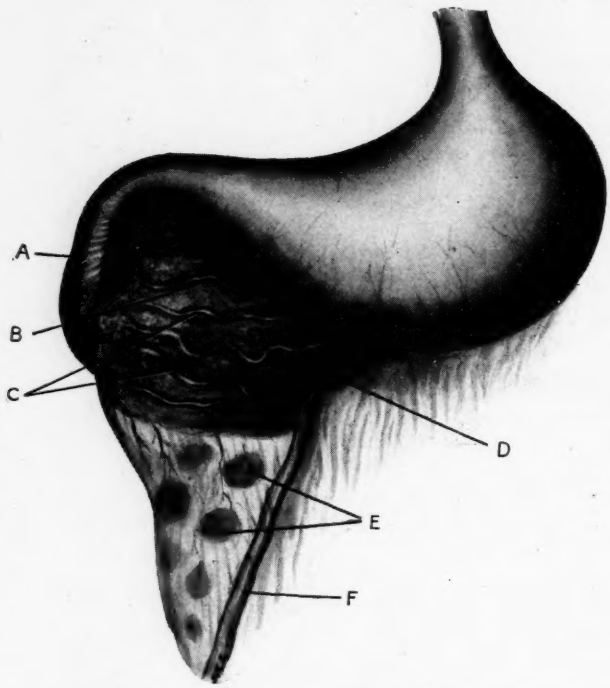


FIG. 331.—Partly diagrammatic drawing showing the condition. A, Duodenum dilated. B, Pancreas. C, Dilated ducts. D, Site of obstruction. E, Patches of (?) fat necrosis in mesentery. F, Small intestine (collapsed).

Thanks to the most skilled and attentive nursing and very careful dieting, the baby gradually strengthened its hold on life. The vomiting slowly waned, the stools became more normal in quality and quantity, and clearly the short circuit was functioning satisfactorily. But despite these satisfactory signs the baby's weight on July 4 (two months after operation) was only 5 lb. 10 oz. The weight record affords one of the chief features of interest in the case. The post-operative fall from 6 lb. 13 oz. on May 1 to 5 lb. 10 oz. on May 21 is noteworthy, and the weight remained unsatisfactory for two months, until the administration of pancreatin began on July 9.

℞	Pepsin	gr. j	℥ss after each feed.
	Pancreatin	gr. j	
	Ol. Caryoph.	℥ $\frac{1}{24}$	
	Mist. Bism.	ʒj	

Almost immediately the child began to gain weight. On Aug. 3 he weighed 7 lb. 2 oz. He was discharged home on Aug. 11, 1922, weighing approximately 7 lb., feeding on 'Cow and Gate Mixture' and pancreatin. He has gone steadily ahead ever since, the only setbacks occurring when the pancreatin mixture was discontinued. It was only found possible finally to drop this about three months after his discharge. The baby is now fat and well, and appears quite normal.

COMMENTS.

This is a case of great interest, which is not a little difficult of explanation. Was the intestinal obstruction primary and the pancreatic condition secondary, or was the obstruction due to a primary pancreatic lesion? The former view would seem more probable. The obstruction was situated at or about the duodenojejunal junction; the duodenum itself, so far as it could be seen, showed no external evidence of abnormality. The absence of jaundice clinically, and the constant presence of bile in the stomach contents, showed that the bile-duct was patent. Under these circumstances the chances of an atresia of the pancreatic duct alone having existed seem remote, though not impossible. According to Keith[1] the pancreas is developed from two processes, each carrying with it its own duct. The ventral process arises in close association with the liver bud, and its duct, the duct of Wirsung, is intimately related to the bile-duct. The dorsal process, which is larger, carries with it its own duct, the duct of Santorini. Normally the terminal portion of the duct of Santorini disappears, and the secretion of that segment of the pancreas developed from the dorsal process is poured into the duct of Wirsung. Nevertheless, occasionally the duct of Santorini may persist in its entirety and open separately into the duodenum. Further, it may happen that the duct of Wirsung does not join the common bile-duct in the normal way, but opens separately into the duodenum.

It will thus be seen that there are possibilities of atresia of the pancreatic ducts apart from a coincident atresia of the bile-ducts. The result of any such atresia would be that the whole or a major part of the pancreas would be deprived of an outlet for its secretions. The existence of such a state of affairs might conceivably give rise to the condition found in this case.

Nevertheless we are inclined to regard the pancreatic lesion as inflammatory, a subacute pancreatitis, secondary to a congenital obstruction in the vicinity of the duodenojejunal junction. The subsequent history of the case supports this view, as the child is now developing quite normally and shows no sign of pancreatic insufficiency. The exact nature of the obstruction to the gut was not determined. There were considerable adhesions about the flexure, and these were not attacked. The small and large intestine were in their normal relationship, and our conclusion was that an atresia existed somewhere in the terminal reach of the duodenum. Gastrojejunostomy was performed to relieve this.

Such a pancreatic lesion as that met with in this case, whether it be regarded as inflammatory or congenital, is rare, and one would imagine that recovery from it would be still more so. We therefore felt it should be placed on record.

REFERENCE.

[1] KEITH, *Human Embryology and Morphology*, 4th ed., 1921, p. 284.

REVIEWS AND NOTICES OF BOOKS.

Thyroid and Thymus. By ANDRÉ CROTTI, M.D., F.A.C.S., LL.D., Columbo, Ohio. Second edition. Large 8vo. Pp. 774, with 105 illustrations in the text and 39 plates in colour. 1923. London: Henry Kimpton. 70s. net.

THE second edition of this great work consists of over 700 pages divided into fifty-two chapters. Most of the first edition has been revised, and a great many chapters have been re-written. A good many new illustrations have been added. The author shows throughout that he has had extensive practical experience of the subject with which he deals, and is well acquainted with microscopical pathology and with surgical literature.

After chapters on the anatomy and physiology of the thyroid, there is a good discussion of modern views on the biochemistry of the gland. The chapter on pathology is illustrated almost entirely from microscopic sections, most of which are good; but *Fig.* 22, supposed to represent a round-celled sarcoma, is scarcely recognizable as such. This chapter would be greatly improved by the addition of drawings or photographs of specimens from the operating theatre or from a pathological museum.

There is a long and good chapter on the etiology of endemic goitre and cretinism. The views of the principal writers on this difficult subject are well summarized. The author accepts as an established fact that the causative factor of goitre, whatever its nature, is most frequently conveyed to the organism through drinking-water. He is not a believer in the theories which seek to establish a correlation between certain geological formations and endemic goitre.

He discusses at considerable length the rather fanciful 'Plutonian theory' of Repin, and, rightly we think, condemns it as "purely hypothetical". The author concludes, probably erroneously, that "heredity is an important factor in the etiology of goitre", a view not infrequently held. The belief of some modern authors that goitre is due to a deficiency of iodine in certain geographical areas he considers "hardly acceptable". The excellent work of McCarrison he discusses fully, and his final cautious conclusion as to the cause of goitre is that "so far the weight of evidence seems to be in favour of the infection theory".

The chapters on the medical treatment of simple goitre and on thyroid grafting are good. Chapter 20, on the indications for operation in simple goitre, shows the author to be an enthusiast for operation. Few surgeons experienced in this branch of practice would agree with him that thyroidectomy "must be undertaken in every case where medical treatment has failed" (p. 323). Surely there are innumerable cases in which medical treatment fails to cure, but in which surgical treatment is nevertheless quite unnecessary so long as the goitre is doing no harm and is not likely to do so. The recommendation of operation for "all colloid, fibrous, cystic goitres", apparently quite irrespective of whether they cause trouble or not, is too sweeping, and will hardly appeal to a judicious surgeon.

The whole subject of exophthalmic goitre is treated at considerable length, and on the whole well. Graves' disease is described (p. 426) as "a thyro-neuro-polyglandular disease caused by a toxic thyroiditis". Chapter 39, on the indications and contra-indications for operation, contains much excellent advice. A warning is rightly given against indiscriminate operating. "When once an operation has been decided upon, the judgment and experience of the surgeon will be largely the determining factors for the safe outcome of the case. Surgeons, because they have done too much, have killed a great number of patients with exophthalmic goitre".

Discussing the treatment of Graves' disease complicated with pregnancy, the author expresses the opinion (p. 423) that in bad cases "a premature Cæsarean section may save the life" of the child. Even in much less severe cases he recommends a "timely thyroidectomy" as the "ideal procedure". We believe this to be teaching to which few surgeons experienced in thyroid surgery would subscribe. The statement that "Basedow patients . . . before entering married life, should have thyroidectomy performed in order to safeguard them against any future exacerbations and to protect their future offspring" we believe to be unsound teaching, not justified by facts.

In his surgical technique of operations upon the thyroid gland (chapter 40) the author is at his best. Good descriptions of the various operations are given, together with the difficulties and dangers, and the best means of avoiding them. The weak point in his case is that very little is said about the actual end-results of his, or indeed of anybody else's, operations, except by bare mortality tables which do not really tell us much. He seems to be a little too ready to conclude that recovery from the operation necessarily means cure of the disease.

In most operations for removal of simple goitre, he usually ties the superior thyroid artery, but does not interfere with the main trunk of the inferior, a proceeding which he rightly considers unnecessary and often harmful. His remarks on this subject (pp. 530, 531) show sound common sense. On the other hand, the advice to give an injection of adrenalin after hæmostasis has been completed "to diminish the chances of post-operative oozing" (pp. 537, 538) appears to us to be a little dangerous. If the hæmostasis has been really complete, adrenalin is unnecessary. If not, the use of this drug may easily induce, in the mind of a less practised surgeon, a false sense of security, since the constriction of blood-vessels produced by adrenalin can only be temporary.

The author speaks with a curious hesitation as to the comparative size of the superior and inferior thyroid arteries, whereas a very little acquaintance with museum specimens of goitre is sufficient to convince anyone that, with rare exceptions, the inferior is the larger artery. His impression that in "thyrotoxic goitres the superior seems to have a larger calibre" is certainly a remarkable statement, not confirmed by examination of the numerous specimens in English museums. His investigations into the number and position of the so-called parathyroids (p. 507) are interesting, and it is refreshing to find an American surgeon stating that "the stereotyped conception of two superior and two inferior parathyroids is far from being correct".

The chapter on anæsthetics is good. While recommending local anæsthesia for many cases, he gives the preference to ether when a general anæsthetic is to be employed. Intratracheal insufflation anæsthesia, "which seemed at first to be full of promise", he has found disappointing. "Just in the cases where it was expected to be the most useful, namely, in goitres with pressure symptoms, it failed to fulfil its expectations."

The last ninety pages of the book are devoted to the thymus gland. A good summary of the anatomy, physiology, and pathology of this organ is followed by an account of the surgical technique of thymectomy. The author is a strong advocate of the combination of thymectomy with thyroidectomy, and considers "this combined operation a great step forward in the surgical treatment of Graves's disease". It may reasonably be doubted, however, whether the operation of thymectomy is quite as easy or as safe as his artistic but semi-diagrammatic illustrations of the operations tend to indicate.

The bibliography, although containing many hundreds of names, is confusing and unsatisfactory. It contains long lists of names of authors arranged under the headings 'thyroid' and 'thymus' respectively, with reference to journals or other publications, but generally without mention of the subject of the paper or any reference to the places in the book where the author may (or may not) have been quoted. There are two indexes. One is a long list of bare surnames, with references to the pages of the book in which these names appear. The index of subjects is good. Three typical instances out of many of the author's rather slipshod methods may be given. On p. 334 reference is made to the conclusions of "Goodal" (*sic*)

in the study of 2250 cases of irritable heart. In the bibliography we find only the names of Goodal, A. and Goodal, J. R. (both names incorrectly spelt), and it is left to the imagination of the reader to ascertain to which of these the quotation in the text is to be ascribed. As a matter of fact, neither the Canadian nor the Scottish author has written on irritable heart, and the source of the statement in the text has obviously been Dr. Strickland Goodall's Chadwick Lecture (*Med. Press and Circ.*, Aug., 1917) on 'soldier's heart', in which 2251 cases of irritable heart are analysed. No reference to the real source of the statement is given anywhere in the text of our author's book, in the bibliography, or in the index. Again, in the bibliography three different authors named Allen are mentioned without reference to the subjects on which they have written. There is no means of knowing with which of these authors the only Allen of the index and text (pp. 446, 636) is to be correlated. Lastly, an observation of Nivet's (misspelt Nevet) concerning the seasonal occurrence of epidemic goitre is somewhat incorrectly quoted on p. 256; but neither in the text nor in the bibliography is any mention made of this author's excellent book, *Traité du Goitre, appuyé sur des Documents statistiques inédits*, a mine of useful information, in which this observation was originally published.

The book is well got up, and misprints are few. Among them are 'teratomata' (p. 80) for teratoma, while on p. 36 the insertion of a comma between Swale and Vincent has unnecessarily bisected the eminent professor into two separate individuals.

The book contains numerous illustrations, many of which are very good. There is room for considerable improvement as regards anatomy in the drawings and diagrams illustrating operations. We do not remember ever having seen the inferior thyroid artery enter the thyroid in the position shown in *Figs.* 83 and 84, nor will the surgeon who attempts ligation of the superior thyroid artery for the first time obtain much practical help from the crude illustrations of this operation as given in *Plate XV*. *Plate VIII*, *Fig.* 1 represents a large retrotracheal goitre springing apparently from the left thyroid lobe. If this be the case, the artist has placed the isthmus behind instead of in front of the trachea. Further, we are asked to believe that this great tumour "separated entirely" the œsophagus and the trachea, and lay between them. If so, the case is quite unique. Retrotracheal goitres are well known, but we believe that they always push the œsophagus to one side, and never pass between these two structures. Indeed, it is difficult to understand how embryologically they could possibly get into such a position. On the other hand, the drawing has been made from an operation case, and it is very easy, in the excitement of such an operation, to mistake the true position of the œsophagus, and we fear that the artist or operator has made such a mistake.

In spite of the numerous criticisms that we have been obliged to make, the book contains a great mass of interesting, useful information. It is a book that should be in the hands of every surgeon who desires to practise thyroid surgery. It is to be hoped that in subsequent editions there will be less about the opinions of others—especially when not derived from original sources—and that we shall hear more about the author's own cases, operations, and results.

Surgery of the Spine and Extremities. By R. TUNSTALL TAYLOR, M.D., Professor of Orthopædic Surgery, University of Maryland, and College of Physicians and Surgeons, Royal 8vo. Pp. 550 + x, with 604 illustrations. 1923. Philadelphia: P. Blakiston's Son & Co. London: Stanley Phillips. 37s. 6d. net.

THIS book covers a great deal of ground, and the 500 or so pages of the volume do not seem to be sufficient for the purpose. While some of the chapters are comprehensive enough and thoroughly sound, it may be confessed at once that many subjects do not receive the attention they deserve, and in some instances the views expressed are not such as would receive general acceptance in this country. The book is patchy, and might have been written by two authors. Perhaps orthopædics is too big a subject for one man to cope with and write well on all the affections nowadays included in this branch of general surgery; and in the future we may see further specialization, though we trust this will not prove to be the case. Space being

limited, it is questionable whether the author is wise in devoting a chapter to historical notes, with copies of ancient illustrations, though no doubt the student will find interest in the dates appended to the names of many great surgeons of the past. A good many pages are devoted to plaster work, apparatus, etc., and precise directions are given as to the requisite quality of the materials used, and where these can be advantageously purchased—information which will no doubt be of the greatest service to the student in America.

As the plane of the ankle-joint is horizontal, we fail to see why, apart from obvious mechanical objections, when inside and outside steels are used, it is advised that the joint of the outer should be at a lower level than that of the inner. Tuberculosis of the spine is dealt with fully. As might be expected, having regard to the nationality of the author, ambulatory treatment of spinal caries and the requisite apparatus are given more attention than they would receive at the hands of a British surgeon.

We think the reader would receive greater help if more definite directions were given as to treatment, and if methods for which the author, in common with most surgeons, has no use were omitted altogether from the book. Scoliosis is fully discussed, the influence of faulty attitudes, etc., being particularly well described.

The chapter on hip disease suffers as much as any from the imperfections of the radiographic reproductions. Many of the radiograms throughout the book are too indistinct to be of the faintest use to anybody. We must again, as we had occasion to do in a recent review of another volume, draw attention to the undesirability, to say the least of it, when dealing with the subject of hip disease, of picturing a *single* Thomas hip splint, a splint which is entirely inefficient either for immobilization or the prevention of deformity. The author favours excision of a tuberculous focus in a bone adjacent to a joint when it shows signs of increasing in size in spite of immobilization of the joint. He would not, we think, be supported by many surgeons of to-day, particularly when he carries the idea to the extent of cutting through a healthy hip-joint to reach a focus in the neck of the femur.

As usual in a book dealing with orthopædic surgery, the subject of coxa vara is dealt with in a way which leaves the reader with no idea as to the author's knowledge or views. The sections on tuberculosis and other affections of the knee-joint are most disappointing. Apparently the only affection of the knee attributable to syphilis is a 'Charcot joint'. And again, in dealing with 'slipping patella', the intimate association of genu valgum is not even mentioned. The pages on flat-foot, on the other hand, are very well written and are thoroughly sound, and so are the chapters on infantile paralysis and spastic paralysis. In dealing with poliomyelitis a good account is given of what might be described as the non-orthopædic side of the subject.

Apart from the radiograms, the book is well and freely illustrated.

Diseases of the Rectum, Anus, and Colon: including the Ileocæcal Angle, Appendix, Colon, Sigmoid Flexure, Rectum, Anus, Buttocks, and Sacrococcygeal Region. By Samuel Goodwin Gant, M.D., LL.D., New York. In three large 8vo volumes, with 1128 illustrations and 10 insets in colour. 1923. London and Philadelphia: W. B. Saunders Co. Per set, £6 6s. 0d. net.

This book is not a revision of previous works by the author, but an entirely new work. As stated by the author in the preface, it is intended to furnish specialists, practitioners, and students with a complete treatise upon the diseases involving the ileocolic angle, appendix, colon, sigmoid flexure, rectum, anus, and perineal region.

The opening chapter contains a brief account of the embryology of the stomach, small intestine, colon, and rectum, and attention is drawn to the chief abnormalities resulting from imperfect development of the small and large intestine.

Chapter 2 deals with the anatomy of the rectum and anus. The description of the arteries and veins is excellent, but that of the lymphatics is rather confusing. Our view is that the lymphatics of the rectum are arranged in two distinct systems, the intramural and the extramural. These lymphatic systems determine the paths by which cancer cells spread from the rectum, and therefore a

clear conception of their anatomical arrangement is of vital importance to those who contemplate the surgery of the cancerous rectum.

Chapter 3 draws attention to the various manifestations indicating the presence of anorectal disease, and the following chapter emphasizes the importance of making a complete examination of the patient in all cases in which rectal symptoms are present. Excellent illustrations of the various instruments in use for examining the rectum are given.

Chapter 6 is devoted to anæsthesia. The various methods of administering anæsthetics are fully discussed, as are also the various anæsthetic agents. The author evinces a strong predilection for local anæsthesia, for which he claims excellent results. He admits, however, that the method is not suitable for all cases, and gives lists of conditions that are favourable and unfavourable to its use.

Chapter 7 deals with malformations of the rectum and anus. The conditions depicted in *Figs.* 122 and 123, in which the anus is shown to have been partially occluded by a fibrous band, must be very rare. The technique of the various operative procedures employed by the author in these cases is fully illustrated.

In chapter 15 fissure in ano is dealt with at considerable length. The author's operation of splitting the anal canal and sphincter seems to us to be a very drastic procedure, as it involves division of both sphincters and the levatores ani. In our experience a fissure can be permanently cured without even dividing any of the fibres of the external sphincter muscle.

In Chapter 17 the various abscesses that may be met with are fully described. The retrorectal abscess shown in *Fig.* 218 is internal to the muscular coat of the bowel. A retrorectal abscess is not only external to the muscular coat of the rectum but is outside the fascia propria as well. We do not agree with the author's views in regard to the etiology of the superior pelvirectal abscess. In our opinion it is invariably due to puncture of the rectal wall by a foreign body from within, and the internal opening is usually situated above the level of the levatores ani and at a considerable distance above the interval between the sphincters. When, however, the abscess has subsequently invaded the ischiorectal fossa, a second internal opening may be found to exist, in the middle line posteriorly, between the sphincters.

Chapter 18 is devoted to the consideration of anorectal fistula. We do not like the author's classification of fistulæ. Types and varieties are mixed up in a confusing manner. We cannot help feeling that the illustrations on page 320 are somewhat imaginative, as we do not recollect having seen a case of a horseshoe fistula in which the burrowing completely encircles the anus, as shown in *Fig.* 239. The various methods of operating upon fistulæ are well described and illustrated. The technique of the various operative procedures is clearly stated, but we question the advisability of producing an intussusception in order to cure a rectovesical fistula, as shown in *Fig.* 277, because when an intussusception commences it usually increases in extent and eventually causes obstruction. Curiously enough, the type of fistula known as the pelvirectal is not described. As this is quite the most extensive fistula that is met with and is extremely difficult to deal with satisfactorily, a detailed description of the operative technique required in such cases would have been extremely acceptable in so comprehensive a work as this. In alluding to fæcal incontinence after fistula operations, the author strikes a correct note when he says that loss of sphincteric control is more often due to faulty after-treatment than to the operation itself. It is a common practice to pack fistula wounds during the after-treatment whenever they are dressed. A depressed furrow-like scar, extending into the anal canal, results in, or is undoubtedly conducive to, incontinence.

In chapter 19 the method of treating internal piles by the injection of a solution of carbolic acid or of quinine and urea receives ample consideration. We agree with the author that this method is useful only in specially selected cases—that is to say, for piles in the first or early second stages of development. It is extremely rare that a permanent cure can be effected, relief being afforded only for a period of from one to two years. The several methods of operating for internal hæmorrhoids are carefully described. There is no doubt that thorough exposure of all the existing piles is essential to success, but we cannot see the necessity of exposing piles by such methods as a suction pump or traction upon a tampon which has previously been

introduced into the rectum, when simpler means amply suffice for the purpose. We are in agreement with the author in his preference for the ligature operation, which in our experience yields uniformly good results. Whitehead's operation is deservedly condemned.

The opening chapter of Volume II deals with the important problem of control of bleeding from the rectum. We do not like the method shown in *Fig.* 364, because it blocks the lumen of the bowel completely and does not provide a passage-way for the escape of flatus. Exception may also be taken to the methods shown in *Figs.* 372 and 373.

Chapter 37 treats of procidentia of the rectum. Many operations for the condition are described and are abundantly illustrated. The author's excision operation appears to differ from Mickulicz's procedure only in the circumstance that he divides the outer layer of the prolapsed gut at some distance from the anus. When, therefore, suturing has been completed, a small portion of the original protrusion remains and has to be reduced at the end of the operation. This portion is apt to become reprotruded, so we prefer the Mickulicz method, by which the whole of the protruded portion of the bowel is removed. Fortunately for dwellers in Europe, the many forms of anorectal ulceration that are described and illustrated in chapter 38 are not often met with.

Chapter 39 is devoted to the important subject of pruritus ani. No new facts are forthcoming in the etiology of this troublesome complaint. We agree with the author in his condemnation of Ball's operation, but as his own button-hole operation performed under local anæsthesia is practically the same idea carried out in a slightly different way, we do not like it any better. We find that quite 80 per cent of cases of pruritus ani are due to definite disease in the anal canal, e.g., internal piles, ulceration of a Morgagnian crypt, fissure, hypertrophied anal papilla, and blind internal fistula, and that the operation which effectively cures these conditions also cures the pruritus. In about 10 per cent the disease is certainly the manifestation of a local neurosis. These cases can be cured by dividing the subcutaneous nerves as in Ball's operation, but symptoms usually recur in from six months to a year.

The succeeding chapters deal with such conditions as skin affections, tuberculosis, lupus, elephantiasis, venereal diseases, and unnatural sexual practices.

In chapter 46 the subject of stricture is fully discussed. The surgical measures advocated for the treatment of stricture are forcible dilatation, internal proctotomy, external proctotomy, excision, proctoplasty, and rectosigmoidostomy. We agree with the author that these procedures are seldom practicable or devoid of risk, and that when a stricture cannot be kept dilated by bougies much the safer plan is to perform colostomy. Chapter 47 is assigned to non-malignant neoplasms. In chapter 48 gas, fæcal, and mucous cysts of the anorectal region are described.

We are disappointed with the chapters dealing with malignant disease. No attention is paid to recent work upon the spread of cancer of the rectum. These observations have clearly shown that an operation undertaken for the cure of cancer must be so planned that the operation field embraces the whole of the tissues that are pathologically known to be liable to invasion by cancer cells which have become detached from the primary growth. It is now recognized that cancer cells spread from the rectum chiefly by means of the extramural lymphatics, which are arranged into three distinct sets, viz., an upward, a lateral, and a downward lymphatic system. It has been established also that a cancerous growth, wherever situated in the rectum, may, while still in an early phase of development, give rise to metastases in either of the three lymphatic areas, or in all of them at the same time. Hence the various tissues through which these lymphatics pass must be regarded as being highly dangerous, and they must be widely removed whenever an operation is undertaken for cancer of the rectum. Failure to appreciate these facts in regard to the spread of cancer from the rectum no doubt explains a surprising statement made by the author on page 233 of Volume II. He states that "the technic of extirpating anorectal cancers and strictures is practically the same". To our minds, there should be an enormous difference between the method employed for excising a rectum which is the seat of non-malignant stricture and that adopted for extirpating the cancerous rectum. We note that the author is in favour of the

vaginal route for removing a cancerous growth of the rectum in women. He claims that by it an excellent exposure is obtained; but a glance at *Fig.* 637 shows the necessity of dividing the bowel quite close to the margins of the growth. The author's method of performing the abdominoperineal operation is by no means a radical measure, because, according to *Fig.* 642, the part of the pelvic mesocolon which contains the inferior mesenteric vessels—along the course of which the upward spread of cancer cells invariably takes place—is left behind.

Volume III deals with colitis, gastro-intestinal toxic disturbances, tuberculosis of the small and large intestine, constipation, and benign and malignant growths of the small and large intestine. These call for no comment, but there are excellent chapters on diverticulosis and the colostomies which are well worth reading.

The book is exceedingly well printed, and the illustrations are numerous and excellent. We strongly recommend it to those who wish to make themselves familiar with the author's personal technique in performing the operations of rectal surgery.

Diseases of the Rectum and Colon and their Surgical Treatment. By J. P. LOCKHART-MUMMERY, F.R.C.S. Demy 8vo. Pp. 872 + x, with 215 illustrations, and 5 in colour. 1923. London: Baillière, Tindall & Cox. 25s. net.

THIS book is a revision of two separate works, *Diseases of the Rectum*, and *Diseases of the Colon*, which are combined into a single and handy volume. We congratulate the author upon having brought the work thoroughly up to date by incorporating recent work in several departments of the subject. The opening chapter gives an excellent account of the anatomy of the rectum and colon, though we doubt whether an anatomist would concur with the statement that the rectum starts slightly to the left of the middle line just below the bifurcation of the aorta. Even the older anatomists considered that the rectum was situated entirely within the cavity of the true pelvis. They held that the rectum was divisible into three parts, and described the first part as extending from the level of the left sacro-iliac synchondrosis to the middle of the third piece of the sacrum. Modern anatomists, however, relegate the first part to the pelvic colon, and describe the rectum as commencing at the middle of the third sacral vertebra.

Chapter 2 deals with the physiology of the large bowel. An interesting account of the experiments carried out to determine the effect of the contents of the colon upon peristalsis is given, and the causation of acute dilatation of the colon and post-operative meteorism is fully discussed. We agree with the view that post-operative meteorism is invariably due to sepsis.

Much useful information is contained in the chapter dealing with examination and diagnosis. The uses of the sigmoidoscope are well described, and several valuable hints are given for guidance when this method of examination is resorted to. The author rightly insists that no force whatever should be used when the sigmoidoscope is being passed, and that, once the instrument has entered the rectum, it should be passed entirely by sight.

Chapter 5 treats of antiseptic technique in relation to operations upon the rectum. By most authorities it is assumed that, owing to the presence of the *Bacillus coli communis* and other bacteria, it is impossible to obtain aseptic conditions in the rectum. It is very gratifying, therefore, to learn that asepsis of the rectal mucosa can be obtained by spending a little time in washing out the rectum with a weak solution (one drachm to the pint) of lysol. Dr. Wyard, pathologist to St. Mark's Hospital, made several bacteriological tests to prove this. He took a series of swabs from the mucous membrane in cases of piles after the parts had been cleansed and just before the operation was begun. The results were in all cases negative.

Chapter 7 contains an account of that interesting condition megacolon or Hirschsprung's disease. The author remarks that no one has been able to offer any really satisfactory explanation of its etiology, and goes on to say that the resulting pathological condition points conclusively to something causing obstruction to the passage of fæcal material along the affected portion of the colon, but fails entirely to reveal an anatomical cause for the obstruction.

Chapter 8 is devoted to the consideration of hæmorrhoids. We confess that we do not follow the author's reasoning when he says on page 157 that "the reason why we suffer from piles is because of the blood in this branch of the plexus having to go into the portal system". We agree that the so-called thrombotic pile is not due to thrombosis at all, but is produced by a local extravasation of blood from a ruptured peri-anal vein. A good account of the various operations that have been devised for the removal of internal piles is given. Preference is shown for the ligature operation as yielding the best results. Whitehead's operation is condemned, the author's principal reason for dislike of the method being that recurrence is frequent. In this connection he says that he has found recurrence to be more common after Whitehead's operation than after any other.

Chapter 10 deals with the subject of prolapse. Prolapse affecting the mucous coat of the bowel only is regarded as an earlier phase of a prolapse which involves the whole of the coats of the rectum. We do not subscribe to this view, and regard them as two totally distinct affections. When discussing the pathology of prolapse, two degrees are described—namely, a first degree in which the mucous membrane covering the outside of the prolapse is continuous with the anal margin of the skin, and a second degree in which there is a definite sulcus between the prolapse and the anal margin (*Figs.* 68 and 69). We would regard the latter as an example of intussusception of the rectum rather than as a degree of prolapse. When treatment is discussed we find mention of a third degree, but its characteristics are not described.

The succeeding five chapters deal with volvulus of the colon, adhesions and kinking of the colon, intussusception, enteroptosis, hernia, and intestinal stasis and chronic constipation. Inflammatory conditions of the rectal mucosa are discussed in the following three chapters, and an excellent account is given of the method of treatment known as cataphoresis. The treatment of ulcerative colitis is fully discussed. We agree that the best surgical procedure is appendicostomy followed by irrigation of the colon.

Chapter 19 contains a good and very clear account of diverticulitis, representing the present state of our knowledge of that curious disease. We agree with the opinion expressed that colostomy, followed at a later date by resection after all inflammatory phenomena have subsided, is the best treatment of the condition. Chapter 21 deals with the subject of abscess. Our conception of an abscess is that it is a localized collection of pus. We do not therefore follow the author's remark on p. 515 that he would not hesitate to cut into one of the abscesses before any pus had formed.

The subject of fistula in ano is considered in Chapter 23. In this, as in many books on the subject, all fistulæ are regarded as belonging to a single type, of which there are several varieties. As a matter of fact, there are several types, each of which presents varieties. The literature upon fistula is particularly meagre, which no doubt accounts for the old classification still prevailing.

Chapter 30 and the three succeeding ones are devoted to malignant disease of the rectum and colon. A good and clear account of the manner in which cancer spreads from the rectum is given, and great importance is attached to accurate knowledge of the anatomy of the lymphatics through which that spread takes place. The chief path by which cancer cells spread from the rectum is along the lymphatics which accompany the inferior mesenteric artery and veins. Spread in this area invariably exists in the specimens that have been removed by operation, that is, in operable cases. It is not possible to remove this lymphatic area by an operation carried out from the perineum, because it is out of reach. Nevertheless, we find that the author prefers the perineal route when operating for cancer of the rectum; in fact he does an operation that is equivalent to removing the breast without clearing the axilla in a case of breast cancer. He reserves the radical or abdomino-perineal operation for advanced cases only, in defiance of the great principle in cancer surgery that the most radical operation for the earliest possible case of cancer means the greatest immunity from recurrence.

We agree that when dealing with a carcinomatous growth of the colon drainage of the proximal portion of the colon—when obstruction exists—should always be carried out before any attempt is made to resect the diseased portion of the bowel.

The suggestion, however, that cæcostomy should be blindly performed in cases of obstruction without determining the nature or seat of the obstruction by exploratory laparotomy does not commend itself to our judgement.

The remaining chapters concern colostomy, the closure of fæcal fistulæ, and injuries to the rectum and colon, and they contain much useful information.

The book is well printed and illustrated. We consider it to be an excellent treatise, and recommend it to those who wish to acquire a sound knowledge of present-day surgery of the rectum and colon.

Diseases of the Male Organs of Generation. By KENNETH M. WALKER, F.R.C.S. Demy 8vo. Pp. 234 + xii. Illustrated. 1923. London: Oxford Medical Publications. 12s. 6d. net.

THIS book forms a valuable addition to the Oxford Medical Publications and can safely be recommended to students and practitioners as containing a very concise and practical description of a most important subject. In several branches of the subject the author's name is well known, and his views thereon are very clearly expressed. In connection with chronic enlargement of the prostate, he is of opinion that the change is not adenomatous, but of the nature of a fibro-epithelial degeneration comparable with that which occurs in the breast, and the first two figures illustrate the histological resemblance of the two conditions. The treatment of prostatic enlargement is very clearly given, and the author rightly insists upon the importance of carrying out any preliminary investigation, such as estimation of the amount of residual urine or cystoscopy, in the patient's own house or in a nursing home, so that he may remain in bed.

In estimating the renal efficiency, the author makes use of the following: the clinical picture, the quantity of urine and its specific gravity, the percentage of urea in the blood, and the urea concentration. The clinical picture is—wisely, we think—placed first on the list. As a rule the presence of over 2 oz. of residual urine is regarded as a strong argument in favour of operation. When the blood urea is above 80 mgrm. per 100 c.c. and the urea concentration under 1·5 per cent, it is considered advisable to perform a preliminary suprapubic cystotomy.

The author's views as to the modes of infection in genital tuberculosis are well known, and the arguments are clearly expressed in support of his opinion that tuberculosis of the testicle, beginning usually in the tail of the epididymis, is the result of a descending infection from a focus in the prostate or vesicles by way of the lymphatics around the vas. In dealing with a malignant tumour of the testicle, the view is expressed that attempts to remove the retroperitoneal lymphatic area cannot be recommended; the testicle and the cord as high as the internal ring should be removed and intensive X-ray treatment adopted. Cautious reference is made to such subjects as the operative treatment of chronic prostatitis and vesiculitis, and the recent attempts to deal with testicular insufficiency. The last two chapters deal with the difficult subjects of sterility and sexual neuroses.

Venereal diseases have been intentionally omitted, and in connection with major surgical procedures the author has dealt more fully with the treatment of the patient before and after operation than with the details of the operation itself.

The book is very readable, and the illustrations are carefully selected, without the desire—too common at the present day—to make them as numerous as possible.

Guy's Hospital Reports, Vol. LXXIII (Vol. III, Fourth Series), No. 4. 1923. London: Oxford Medical Publications. Subscription £2 2s. 0s. Single Number 12s. 6d. net.

EIGHTEEN separate articles are included in this issue, but only a few of them are of surgical interest. These include a résumé of the operative treatment of exophthalmic goitre and the records of a few rare cases.